Pebble Project

NORTHERN DYNASTY MINES INC.

DRAFT ENVIRONMENTAL BASELINE STUDIES
2004 PROGRESS REPORTS

CHAPTER 12. MARINE

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ACRONYMS

AASHTO	American Association of State and Highway Transportation Officials
ABA	acid-base accounting
ac-ft	acre-feet
ADEC	Alaska Department of Environmental Conservation
ADF&G	Alaska Department of Fish and Game
ADNR	Alaska Department of Natural Resources
ADOT/PF	Alaska Department of Transportation and Public Facilities
agl	above ground level
AHRS	Alaska Heritage Resource Survey
ALS	ALS Environmental Laboratory
ANCSA	Alaska Native Claims Settlement Act
AP	acid potential
APE	area of potential effect
ASCI	Alaska Stream Condition Index
ASTM	American Society for Testing and Materials
ASTt	Arctic Small Tool tradition
BBNA	Bristol Bay Native Association
BEESC	Bristol Environmental & Engineering Services Corporation
bgs	below ground surface
BLM	Bureau of Land Management
BP	before present
BTEX	benzene, toluene, ethylbenzene, and xylenes
ºC	degrees Celsius
^{14}C	Carbon 14
CEMI	Canadian Environmental and Metallurgical Laboratory
cfs	cubic feet per second
CIRCAC	Cook Inlet Regional Citizens Advisory Council
cm	centimeter(s)
CPUE	catch per unit effort
CQ	continuous flow
CRM	cultural resources management
CUEQ%	copper equivalent grade
DEM	digital elevation model
DI	deionized
DRO	diesel-range organics

EBD	environmental baseline document
EIS	environmental impact statement
EPT	Ephemeroptera, Plecoptera, or Trichoptera
EPA	Environmental Protection Agency
FAA	Federal Aviation Administration
FHWA	Federal Highway Administration
FL	fork length
fps	feet per second
FR	Federal Register
ft	foot (feet)
ft^2	square foot (feet)
g	gram(s)
GIS	geographic information system
GLM	general linear model
GMU	Game Management Unit
gpm	gallons per minute
GPS	global positioning system
GRO	gasoline-range organics
GS	gauging station
HC-3	high-gradient, contained channel
HDR	HDR Alaska, Inc.
HWM	high-water mark
ICP	inductively coupled plasma
IIE	Iniskin/Iliamna Estuary
IQ	instantaneous flow
KC	Kaskanak Creek
km^2	square kilometers
KP	Knight Piesold
KR	Koktuli River Main Stem
L	liter(s)
LC-1	low-gradient, contained channel
LIDAR	light detection and ranging
m	meter(s)
m^2	square meter(s)
M.A.	Master of Arts
MC-1	moderate-gradient, narrow, shallow, contained channel
MCHTWG	Mulchatna Caribou Herd Technical Working Group
MDC	mine development concept

me-Hg	methyl-mercury
MEND	mine environment neutral drainage
mg	milligram(s)
mg/kg	milligrams per kilogram
mg/l	milligrams per liter
mi^2	square mile(s)
ml	milliliter(s)
ML/ARD	metal leaching/acid rock drainage
MLLW	mean lower low water
mm	millimeter(s)
MM-1	moderate-gradient, mixed-control channel
MMS	Minerals Management Service
MODIS	moderate resolution imaging spectroradiometer
mph	miles per hour
m/s	meters per second
µL	microliter(s)
NASA	National Aeronautics and Space Administration
ND	non-detect
NDM	Northern Dynasty Mines Inc.
NEPA	National Environmental Policy Act
NK	North Fork Koktuli River
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NP	neutralization potential
NPS	National Park Service
NRCS	Natural Resources Conservation Service
NRHP	National Register of Historic Places
Nv	calculated variance
NWR	National Wildlife Refuge
OCSEAP	Outer Continental Shelf Environmental Assessment Program
OHMP	Office of Habitat Management and Permitting
OHW	ordinary high water
PA-1	narrow, placid-flow habitat
PA-3	shallow-ground, water-fed slough
PA-5	palustrine beaver habitat
PAG	potentially acid-generating
PSD	Prevention of Significant Deterioration
PVC	polyvinyl chloride

Q	discharge
QA	quality assurance
QAPPP	quality assurance project plan
QC	quality control
RBP	Rapid Bioassessment Protocols
RRO	residual-range organics
SHPO	State Historic Preservation Officer
SK	South Fork Koktuli River
SLR	SLR Alaska
SRB&A	Stephen R. Braund & Associates
SRK	SRK Consulting (Canada) Inc.
SWE	snow/water equivalent
TOC	total organic carbon
TSS	total suspended solids
UAF	University of Alaska Fairbanks
USC	United States Code
USDA	United States Department of Agriculture
USDI	United States Department of Interior
USFS	United States Forest Service
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
UT	Upper Talarik Creek
VHF	very high frequency
WMC	Water Management Consultants Inc.
WRIR	water-resources investigations report

12. MARINE STUDIES—PORT

12.1 Marine Birds and Mammals

12.1.1 Introduction

This section presents the preliminary findings of the 2004 marine wildlife study. This study examined the distribution and abundance of marine wildlife (marine-oriented birds and marine-oriented mammals) during two sampling periods in 2004: summer and late fall/winter. The surveys focused on threatened/endangered species (e.g., Steller's Eiders [*Polysticta stelleri*]), species being considered for listing under the Endangered Species Act (e.g., Kittlitz's Murrelet [*Brachyramphus brevirostris*]), depleted or rare species of marine mammals (e.g., beluga whales [*Delphinapterus leucas*], Steller sea lions [*Eumetopias jubatus*]), marine-oriented birds in general (including breeding species), and marine-oriented mammals.

12.1.2 Study Objectives

The goal of the study was to determine the seasonal distribution and abundance of marine-oriented birds and mammals in the potential port areas that could be affected by port facilities and by the passage of ships through the area. Special emphasis was placed on endangered species, such as Steller's Eiders, and on species that have been nominated for listing under the Endangered Species Act, such as Kittlitz's Murrelets. Emphasis also was placed on rare mammals, such as beluga whales and Steller sea lions. The specific objectives of this study were as follows:

- Survey the distribution and abundance of marine-oriented birds and mammals in the potential port areas with standardized boat-based surveys during two sampling periods (summer, late fall/winter).
- Describe the seasonal species-composition of the marine-oriented bird community.
- Determine and describe the use of the potential port areas by Steller's Eiders and Kittlitz's Murrelets so that, if either species occurs there, strategies can be developed to minimize impacts.

12.1.3 Study Area

The study area included the proposed port areas, including associated bays, offshore islands, and nearby open coastline (Figure 12-1). Specific areas surveyed include the following:

- The shorelines of Iniskin Bay and Iliamna Bay.
- The shoreline of the nearby outer coastline (east almost to Oil Bay and south to Ursus Head).
- Islands and islets near the mouth of Iniskin Bay (the Mushroom Islets and Scott, Vert, Iniskin, and Pomeroy islands).
- Islands and islets near the mouth of Iliamna Bay (White Gull Island, Turtle Reef, and Black Reef).

- Deeper water in the centers of Iliamna and Iniskin bays and in the open bight to the southeast of them.

The study area included both nearshore waters and adjacent coastline, and offshore waters; hence, surveys were conducted in all habitats used by marine wildlife that potentially could be affected by a port facility and boat traffic.

12.1.4 Scope of Work

The research and field work for this study were conducted during 2004. The study was conducted by Dr. Robert H. Day of ABR, Inc., Fairbanks. The study was conducted according to the approach described in the *Draft Environmental Baseline Studies, Proposed 2004 Study Plan* (NDM, 2004b). In summary, this study was designed to:

- Measure the distribution and abundance of marine wildlife (marine-oriented birds and marine-oriented mammals) in the port area with two types of standardized surveys (nearshore and offshore);
- Plot locations of marine wildlife recorded during nearshore surveys and later digitize those locations; and
- Describe sex and age classes, habitat use, and activity of marine wildlife.

12.1.5 Methods

Boat-based surveys for marine birds and mammals were conducted in Iniskin and Iliamna bays in early summer (June 21-25) and late fall/early winter (December 9-13) 2004. Both nearshore and offshore surveys were conducted, as described in the *Draft Environmental Baseline Studies, Proposed 2004 Study Plan* (NDM, 2004b). All nearshore surveys were conducted from a skiff that followed the shoreline approximately 100 feet (30 meters) from shore (Figure 12-1). During each nearshore survey, researchers identified, counted, and mapped all birds and mammals seen in the nearshore zone (≤650 feet [≤200 meters] from shore, on the beach, or ≤325 feet [≤100 meters] inland) or birds flying over it (not mapped). Offshore surveys were conducted as a series of strip-transects in the offshore zone (central portion) of each bay and in the bight that encompasses both bays. During these offshore surveys, the ship's speed, the time, and the beginning and ending coordinates for each transect were recorded, and all birds and mammals seen within approximately 500 feet (150 meters) on either side of the boat were counted. The midpoints of each sampling transect were used to map abundance of each species on the offshore transects. For both sampling methods, counts were converted to estimates of animals per square mile ($/mi^2$) and per square kilometer ($/km^2$) of area surveyed.

In the summer sampling period, researchers also searched for and attempted to census colonies of nesting seabirds on the islands around the mouths of Iniskin and Iliamna bays. Because of concerns about excessive disturbance of nesting colonies, however, researchers did not land and conduct extensive counts of nests, searches of nesting burrows, or any other evidence of nesting numbers.

Although the 2004 study plan (NDM, 2004b) indicated that the late fall/winter sampling would be conducted in November, sampling could not be conducted at that time. Weather in the fall of 2004

included numerous low-pressure systems tracking through the northern Gulf of Alaska in quick succession. Consequently, a window of suitable weather did not occur until almost mid-December.

12.1.6 Results and Discussion

The marine-wildlife study team successfully completed surveys of the entire study area in summer 2004 and was able to survey nearly the entire area in late fall/winter 2004. During the latter survey, seas around Black Reef (an exposed set of small islands between the mouths of Iliamna and Iniskin bays) were too rough for small-boat work; however, it is believed that the absence of those data will not affect the results or conclusions because densities always are standardized as the number of individuals divided by the area of the nearshore zone sampled.

12.1.6.1 Birds

In summer 2004, researchers recorded at least 25 species of marine-oriented birds on the nearshore survey (Table 12-1) and at least 14 species of marine-oriented birds on the offshore survey (Table 12-2). Overall, densities of marine-oriented birds averaged 48.8 birds/mi^2 (126.4/km^2) on the nearshore survey and 9.0 birds/mi^2 (23.4/km^2) on the offshore survey in summer 2004 (Tables 12-1 and 12-2, respectively). On the nearshore survey, Glaucous-winged Gulls dominated numerically, composing nearly 40 percent of all birds seen, followed in decreasing densities by Harlequin Ducks, Surf Scoters, and Pelagic Cormorants: these four species combined composed approximately 80 percent of all birds seen. On the offshore survey, White-winged Scoters dominated numerically, composing approximately 40 percent of all birds seen, followed in decreasing densities by Glaucous-winged Gulls and Black-legged Kittiwakes: these three species combined composed approximately 80 percent of all birds seen. In addition, several large flocks of scoters were seen in the centers of the bays, but they were off-survey. (Note: scientific names of wildlife species recorded during surveys in 2004 are given in Tables 12-1 and 12-2.)

TABLE 12-1
Mean densities of marine-oriented birds and mammals observed on transect during two nearshore surveys, summer and late fall/winter 2004[1]

Species	Survey[1]	
	Summer	Late Fall/Winter
BIRDS		
Mallard, *Anas platyrhynchos*	0.9 (2.4)	0.1 (0.2)
Northern Pintail ,*Anas acuta*	<0.1 (0.1)	0
Greater Scaup, *Aythya marila*	0.7 (1.9)	0
Steller's Eider, *Polysticta stelleri*	0	— [2]
Common Eider, *Somateria mollissima*	0.1 (0.2)	0
Harlequin Duck, *Histrionicus histrionicus*	6.9 (18.0)	1.8 (4.7)
Surf Scoter, *Melanitta perspicillata*	6.8 (17.5)	0.1 (0.2)
White-winged Scoter, *Melanitta fusca*	0.7 (1.9)	0
Black Scoter, *Melanitta nigra*	0.4 (1.1)	1.2 (3.0)
Long-tailed Duck, *Clangula hyemalis*	0	3.3 (8.5)
Bufflehead, *Bucephala albeola*	0	0.2 (0.6)
Common Goldeneye, *Bucephala clangula*	0	0.8 (2.2)
Barrow's Goldeneye, *Bucephala islandica*	0	1.9 (4.8)

Species	Survey[1]	
	Summer	**Late Fall/Winter**
Unidentified goldeneye, *Bucephala* sp.	0	1.4 (3.6)
Common Merganser, *Mergus merganser*	1.2 (3.2)	0.1 (0.3)
Red-breasted Merganser, *Mergus serrator*	0	<0.1 (<0.1)
Unidentified merganser, *Mergus* spp.	0	<0.1 (0.1)
Unidentified duck	0	0.3 (0.9)
Pacific Loon, *Gavia pacifica*	<0.1 (0.1)	<0.1 (0.1)
Common Loon, *Gavia immer*	<0.1 (0.1)	0
Unidentified loon, *Gavia* spp.	0	<0.1 (0.1)
Horned Grebe, *Podiceps auritus*	0	<0.1 (<0.1)
Double-crested Cormorant, *Phalacrocorax auritus*	1.1 (2.9)	0
Red-faced Cormorant, *Phalacrocorax urile*	1.0 (2.7)	0
Pelagic Cormorant, *Phalacrocorax pelagicus*	3.0 (7.8)	0.1 (0.2)
Unidentified cormorant, *Phalacrocorax* sp.	0	0.2 (0.5)
Bald Eagle, *Haliaeetus leucocephalus*	0.3 (0.7)	0.2 (0.4)
Golden Eagle, *Aquila chrysaetos*	<0.1 (<0.1)	0
Black Oystercatcher, *Haematopus bachmani*	0.4 (1.1)	0
Spotted Sandpiper, *Actitis macularia*	<0.1 (<0.1)	0
Rock Sandpiper, *Calidris ptilocnemis*	0	3.5 (9.0)
Mew Gull, *Larus canus*	0.4 (1.0)	0.4 (1.1)
Herring Gull, *Larus argentatus*	0	0.1 (0.2)
Glaucous-winged Gull, *Larus glaucescens*	19.0 (49.3)	1.0 (2.6)
Black-legged Kittiwake, *Rissa tridactyla*	2.4 (6.2)	0
Unidentified gull	0	0.1 (0.2)
Common Murre, *Uria aalge*	0	0.2 (0.4)
Pigeon Guillemot, *Cepphus columba*	1.8 (4.7)	0
Marbled Murrelet, *Brachyramphus marmoratus*	<0.1 (0.1)	0.2 (0.5)
Unidentified murrelet, *Brachyramphus* sp.	<0.1 (<0.1)	0
Horned Puffin, *Fratercula corniculata*	1.2	0
Tufted Puffin, *Fratercula cirrhata*	2.0	0
Black-billed Magpie, *Pica pica*	<0.1 (0.1)	0.2 (0.5)
Common Raven, *Corvus corax*	0.1 (0.3)	<0.1 (0.1)
Total birds	**48.8 (126.4)**	**17.3 (44.9)**
MAMMALS		
River otter, *Lontra canadensis*	0	<0.1 (0.1)
Sea otter, *Enhydra lutris*	<0.1 (0.1)	1.7 (4.4)
Harbor seal, *Phoca vitulina*	7.5 (19.5)	0.3 (0.9)
Gray Whale, *Eschrichtius robustus*	— [2]	0
Total mammals	**7.6 (19.6)**	**2.1 (5.5)**

1. Densities are shown in number per square mile (number per square kilometer).

2. Recorded only during off-sampling period or only outside of the sampling zone.

TABLE 12-2
Mean densities of marine-oriented birds and mammals observed on transect during two offshore surveys, summer and late fall/winter 2004[1]

Species	Survey[1]	
	Summer	**Late fall/winter**
BIRDS		
Common Eider	0	<0.1 (0.1)
Surf Scoter	0.2 (0.4)	0
White-winged Scoter	3.7 (9.5)	0.1 (0.3)
Long-tailed Duck	0	0.2(0.6)
Short-tailed Shearwater, *Puffinus tenuirostris*	<0.1 (0.1)	0
Double-crested Cormorant	0.2 (0.4)	0
Red-faced Cormorant	<0.1 (0.1)	0
Pelagic Cormorant	0.1 (0.3)	0
Unidentified cormorant	0	0.3 (0.8)
Parasitic Jaeger, *Stercorarius parasiticus*	<0.1 (0.1)	0
Mew Gull	0	0.1 (0.2)
Glaucous-winged Gull	1.9 (4.9)	0.3 (0.9)
Black-legged Kittiwake	1.6 (4.1)	<0.1 (0.1)
Common Murre	0.5 (1.3)	0
Pigeon Guillemot	0.1 (0.3)	0
Marbled Murrelet	0.2 (0.4)	0
Horned Puffin	0.3 (0.9)	0
Tufted Puffin	0.3 (0.8)	0
Total birds	**9.0 (23.4)**	**1.1 (2.9)**
MAMMALS		
Sea otter	<0.1 (0.1)	0.4 (1.1)
Dall's porpoise, *Phocoenoides dalli*	<0.1 (0.1)	0
Total mammals	**<0.1 (0.1)**	**0.4 (1.1)**

1. Densities are shown in number per square mile (number per square kilometer).

In summer 2004, the highest densities of all birds combined occurred at or near the mouths of Iliamna and Iniskin bays (Figure 12-2). Many of these birds were concentrated on offshore islands, several of which were used for nesting by these birds (Figure 12-3); additional areas used for nesting included cliffs and small islets just off the mainland, talus slopes on the mainland, and trees. Species recorded as breeding included (in decreasing order of abundance), Tufted Puffins, Pigeon Guillemots, Pelagic Cormorants, Horned Puffins, Glaucous-winged Gulls, Double-crested Cormorants, and Bald Eagles. Surprisingly, the numbers of nesting seabirds that were recorded was much smaller than those recorded many years ago in the *Alaska Seabird Colony Catalog* published by the U.S. Fish and Wildlife Service (USFWS) (Figure 12-4). The marine-wildlife study team is attempting to access USFWS archives to see the original survey data. We recorded no Kittlitz's Murrelets in summer 2004, although we did see unidentified

Brachyramphus murrelets that may have been Kittlitz's. In addition, densities of Harlequin Ducks were high during this time.

In late fall/winter 2004, researchers recorded at least 23 species of marine-oriented birds on the nearshore survey (Table 12-1) and at least seven species on the offshore survey (Table 12-2). In addition, a pair of Steller's Eiders was recorded just north of the mouth of Iniskin Bay, off transect. This was the only record of a threatened/endangered species in 2004.

Overall, densities of marine-oriented birds in late fall/winter 2004 averaged 17.3 birds/mi^2 (44.9/km^2) on the nearshore survey (Table 12-1) and 1.1 birds/mi^2 (2.9/km^2) on the offshore survey (Table 12-2). On the nearshore survey, Rock Sandpipers dominated numerically, composing approximately 20 percent of all birds seen, followed in decreasing densities by Long-tailed Ducks, Barrow's Goldeneyes, Harlequin Ducks, Black Scoters, and Glaucous-winged Gulls: these six species combined composed approximately 73 percent of all birds seen. We recorded no Kittlitz's Murrelets in late fall/winter 2004, although the species may have been present in very low numbers. In addition, densities of Harlequin Ducks were moderate to high during this time. On the offshore survey, Glaucous-winged Gulls dominated numerically, composing approximately 32 percent of all birds seen, followed in decreasing densities by Long-tailed Ducks and unidentified cormorants: these three species combined composed approximately 80 percent of all birds seen.

In the late fall/winter, the highest densities of all birds combined occurred at or near the mouth of Iliamna Bay and at the head of Iniskin Bay (Figure 12-5). The latter concentration was primarily a large flock of wintering Rock Sandpipers.

12.1.6.2 Mammals

In summer 2004, researchers recorded at least two species of marine-oriented mammals on the nearshore survey (Table 12-1) and at least two species on the offshore survey (Table 12-2). In addition, during the nearshore survey one species of marine-oriented mammal—a gray whale (*Eschrichtius robustus*)—was recorded outside of the survey zone just north of the mouth of Iniskin Bay. Overall, densities of marine-oriented mammals during the summer survey averaged 7.6 mammals/mi^2 (19.6/km^2) on the nearshore survey (Table 12-1) and <0.1 mammals/mi^2 (0.1/km^2) on the offshore survey (Table 12-2). On the nearshore survey, harbor seals dominated numerically, composing approximately 93 percent of all mammals seen; they were not observed on the offshore survey. Researchers also recorded low numbers of sea otters on the nearshore survey, and sea otters and Dall's porpoises on the offshore survey. No beluga whales or Steller sea lions were recorded during the summer surveys.

In late fall/winter 2004, at least three species of marine-oriented mammals were recorded on the nearshore survey (Table 12-1) and at least one species on the offshore survey (Table 12-2). Overall, densities of marine-oriented mammals during the fall/winter survey averaged 2.1 mammals/mi^2 (5.5/km^2) on the nearshore survey and 0.4 mammals/mi^2 (1.1/km^2) on the offshore survey. On the nearshore survey, sea otters dominated numerically, composing approximately 80 percent of all mammals seen; low numbers of river otters and harbor seals also were recorded. On the offshore survey, sea otters were the only mammal species recorded. No beluga whales or Steller sea lions were recorded during the late fall/winter surveys.

Two dominant species of marine mammals, harbor seals and sea otters, differed seasonally in abundance and distribution. In summer 2004, only two sea otters were observed in the study area, one at Black Reef

during the nearshore survey and another during the offshore survey (Figure 12-6). In contrast, in late fall/winter 2004, sea otters occurred in high densities near White Gull Island and in the complex of islands southeast of the mouth of Iniskin Bay (Figure 12-7). In summer 2004, harbor seals occurred in high densities in the complex of islands southeast of the mouth of Iniskin Bay and at or near the mouth of Iliamna Bay (Figure 12-8). In addition, aerial observers conducting wildlife surveys often saw 50 to 100 seals concentrated near the mouths of two streams in upper Iniskin Bay, but that area was too shallow to be surveyed well by boat. In late fall/winter 2004, harbor seals occurred in low numbers with no notable concentration areas (Figure 12-9).

12.1.7 Summary

The distribution and abundance of marine-oriented birds and mammals were surveyed in the proposed port area during two periods in 2004: summer and late fall/winter. During each sampling period, researchers determined densities of birds and mammals near or on the shoreline with nearshore surveys. Offshore surveys were conducted to determine densities in deeper waters, in the centers of bays, and in the bight that encompasses both bays.

Densities of birds on both nearshore and offshore surveys were considerably higher in the summer than in the late fall/winter. In addition, species composition, species dominance, and distribution changed seasonally, with birds concentrating near the mouths of the bays in the summer but retreating into the bays in winter. Several species of birds also bred in the area, including (in order of abundance) Tufted Puffins, Pigeon Guillemots, Pelagic Cormorants, Horned Puffins, Glaucous-winged Gulls, Double-crested Cormorants, and Bald Eagles.

The surveys were designed to locate any threatened or endangered wildlife species that might occur in the port area. Researchers recorded no Steller's Eiders in the summer, but recorded one pair in the fall/winter outside the survey area. No Kittlitz's Murrelets were recorded during either season, although it still is possible they may occur in the area in low numbers. Researchers recorded high densities of Harlequin Ducks, which previously were proposed for listing as a threatened/endangered species.

Densities of mammals on nearshore surveys were considerably higher in the summer than in the late fall/winter, whereas densities on offshore surveys were slightly higher in the late fall/winter than in the summer. In addition, species composition and species dominance changed seasonally, with harbor seals dominating numerically in the summer and sea otters dominating in the fall/winter. Preliminary review of the literature suggests that this is the highest concentration of harbor seals in Cook Inlet. No beluga whales or Steller sea lions were recorded during the surveys.

12.2 Marine Habitat and Aquatic Resources

12.2.1 Introduction

This section presents the findings of 2004 studies investigating marine water and sediment quality, fish, invertebrates, and flora for the Pebble Project in Iniskin and Iliamna Bays during August/September 2004. Iniskin and Iliamna bays (Figure 12-10) comprise one of several estuarine complexes and embayments along the west side of lower Cook Inlet. Little scientific investigation of these areas had occurred prior to the initiation of the National Oceanic and Atmospheric Administration’s (NOAA’s) Outer Continental

Shelf Environmental Assessment Program (OCSEAP) in the mid-1970s. In 1976, Lees (1977) conducted an initial reconnaissance of intertidal habitats and their assemblages in Iniskin Bay. In 1978, NOAA established a field camp in Cottonwood Bay that allowed for more intensive repeated sampling of several aspects of the environment of the Iniskin/Iliamna Estuary (IIE). A group led by investigators in the present study established several intertidal stations within the IIE and sampled them in 1978 (Lees et al., 1980) and again in 1996 (Pentec, 1996). While the study team has a high confidence that areas sampled at these stations in 2004 consistently sampled the same areas, or even the same patches of rock, that were sampled in 1978 and 1996, caution should be exercised in making comparisons between the 2004 intertidal observations and data from the earlier studies because of differences in the times of year when sampling occurred.

In contrast, few previous studies have been conducted to characterize subtidal habitats in the IIE. No subtidal sampling had occurred at the four sites under consideration as potential port sites at the time of the 2004 reconnaissance program. Some shallow subtidal diver transects were completed in 1978 (Lees et al., 1980) at Scott Island, Knoll Head Lagoon, and White Gull Island, but no quantitative subtidal sampling occurred there. Prior to 2004, the nearest quantitative subtidal sampling to the IIE occurred in lower Cook Inlet as part of the OCSEAP program (Feder et al., 1980) and was conducted considerably offshore from the proposed port-site alternatives.

Conclusions from the 2004 field sampling in intertidal and subtidal habitats in the IIE, as well as the beach seine and trawl programs, must be tempered with the recognition that this most recent sampling was conducted at only one time of year (late summer) and during a single open-water season.

12.2.2 Study Objectives

12.2.2.1 General

Sampling design, methods, and data from earlier studies provided the basis for the marine reconnaissance study conducted in 2004 to identify existing conditions in the IIE. Specific objectives of this work were as follows:

- Supplement knowledge already available from long-term study sites with a broader understanding of the ecology of the IIE.
- Gather new information on specific habitats that may be at risk from infrastructure-development alternatives.
- Identify specific habitats or resources that will be important to regulators (e.g., kelp and eelgrass beds, stream-mouth marshes, shellfish-resource areas, threatened or endangered species habitats, etc.).
- Obtain samples to establish baseline levels of metal and hydrocarbon contaminants in sediments, water, and biota.
- Provide a basis for possible more-detailed studies to be completed in 2005 at potential facility locations.

Specific tasks were performed in the intertidal and subtidal habitats to meet the overall study objectives. Pentec, the University of Alaska Fairbanks (UAF), and RWJ Consulting (RWJ) worked cooperatively in

all aspects of the field work under the direction of Bristol Environmental and Engineering Services Corporation (BEESC) and on behalf of Northern Dynasty Mines Inc. (NDM). In general, Pentec had primary responsibility for the intertidal reconnaissance, whereas UAF and RWJ Consulting had primary responsibility for the subtidal reconnaissance.

12.2.2.2 Intertidal Study

Tasks performed in 2004 specific to IIE intertidal habitats were as follows:

- Mapping and characterization of intertidal habitat.
- Description of typical assemblages on major habitat types and in the several vertical zones or "biobands" at selected sites.
- Comparison of 2004 conditions with conditions documented in earlier work in the area.
- Collection of infauna samples for quantitative analysis.
- Assessment of fish use of littoral habitat in intertidal and shallow subtidal areas by beach seining and otter trawling, respectively.
- Collection of littoral sediment and animal tissues for laboratory analysis of baseline metals and hydrocarbon concentrations.

12.2.2.3 Subtidal Study

Tasks performed in 2004 specific to IIE subtidal habitats were as follows:

- Comparison of 2004 conditions with conditions documented in earlier work in the general project area.
- Collection of subtidal sediments and animal tissues for laboratory analysis of baseline metals and hydrocarbon concentrations.
- Collection of infauna samples for quantitative analysis.
- Collection of offshore water samples for laboratory analysis of physical characteristics and contaminants.
- Collection of pelagic and demersal fish in offshore subtidal areas with otter trawling for species identification and tissue analyses for baseline metals concentrations.

12.2.3 Study Area

The sampling effort in August/September 2004 focused on intertidal and offshore areas at or near four port-site alternatives and along shorelines that would be impacted by road routes under consideration at that time. Figure 12-10 shows key features in the IIE considered for the reconnaissance study. Port sites investigated were identified in the *Draft Iliamna Regional Transportation Corridor Analysis* (PN&D, 2004), and include the following:

- Port Site 1—Knoll Head.
- Port Site 1a—Knoll Head West (the previously sampled Knoll Head site).

- Port Site 1b—Knoll Head East, between Port Site 1 and Port Site 2.
- Port Site 2—west entrance to Iniskin Bay.
- Port Site 3—Diamond Point (north entrance to Cottonwood Bay).
- Port Site 4—North Head (north entrance to Iliamna Bay).

Additional intertidal sampling was conducted at three other locations:

- Port Site Existing (northern Iliamna Bay near Williamsport).
- Scott Island (historic rocky intertidal survey area).
- Blackie Beach (historic intertidal sand/mud survey area).

Additional subtidal sampling was conducted at two other locations:

- White Gull Island (historic subtidal survey area).
- OPP1—Offshore of the Potential Port (within probable navigation channel to potential port).

12.2.4 Scope of Work

The background-literature research, planning, and field work for this study were conducted by the project team during 2004. Field work was conducted between August 27 and September 1 and included the following components:

- Aerial Reconnaissance—conducted by Dr. Jon Houghton of Pentec and Dr. Stephen Jewett of UAF.
- Intertidal Studies
  - Intertidal reconnaissance (including both quantitative and qualitative data collection) were conducted by Dr. Houghton, Mr. Dennis Lees of Littoral and Ecological Services, and Dr. Sandra Lindstrom, a private consultant.
  - Intertidal sample collection (including samples for sediment-chemistry, infauna, and biological-tissue analysis) was conducted by the above intertidal personnel plus Mr. Jim Starkes of Pentec.
  - Beach seining was conducted by the above intertidal personnel.
- Subtidal Studies
  - Subtidal reconnaissance (including both quantitative and qualitative data collection and underwater photography) was conducted by UAF marine biologists/divers Dr. Jewett, Mr. Shawn Harper, and Ms. Heloise Chenelot; marine technician Mr. Gerald Douthit of NW-GEOSciences; and Ms. Lee Ann Gardner of RWJ Consulting.
  - Subtidal sample collections (including samples for sediment/water-chemistry, infauna, and biological-tissue analysis) were conducted by the above subtidal personnel with assistance by Mr. James Nardelli—skipper of the *R*/V *Kittiwake II*—and Mr. Dan Strickland—first mate.

- Otter trawling, setting of crab and shrimp pots, and hook and line sampling were conducted by all of the above intertidal and subtidal personnel.

The study was conducted according to the approach described in the *Draft Environmental Baseline Studies, Proposed 2004 Study Plan* (NDM, 2004b) and in the project-specific *Draft Environmental Baseline Studies, Proposed 2004 Quality Assurance Project Plan* (QAPPP; NDM, 2004a). Detailed methods are described in these documents and are only briefly summarized in the following section unless the methods/techniques used differed from those identified in the QAPPP and study plan.

12.2.5 Methods

12.2.5.1 Literature Synthesis

Senior biologists with Pentec, UAF, and RWJ Consulting are continuing to prepare a literature synthesis relevant to the project area. The synthesis will include a general description of the geologic, hydrodynamic, and climatological forces that provide the context for the biological productivity of lower Cook Inlet. Sources consulted for this review are summarized in Appendix 12-A. Results of this task will be reported at a later time.

12.2.5.2 Field Surveys and Collections

Littoral and subtidal habitats in lower Cook Inlet have high importance as areas of diversity and productivity that support numerous species of ecological and economic importance. Some of the species (relict arctic biota) appear have biogeographical importance as well. To evaluate the potential impacts of port development alternatives on these resources, it is necessary to understand what specific resources present in the project area would be affected by the transportation alternatives under consideration.

The 2004 marine reconnaissance studies were supported by a large vessel platform, the *R/V Kittiwake II*. This 73-foot vessel was capable of transporting and housing up to 10 scientists. Intertidal and subtidal sites were accessed via skiff. The 2004 field program for marine reconnaissance began with the *R/V Kittiwake II* departing Homer, Alaska, on August 26, 2004 and arriving at the IIE on August 27. Sampling and habitat characterization began on August 27 and were completed on September 1. The vessel, crew, and samples returned to Homer on September 2.

Aerial Reconnaissance

To gain a greater familiarity with the overall mosaic of habitats present in the IIE, an aerial reconnaissance of the area's shorelines was conducted. The flight was planned to coincide with clear weather and a low tide (e.g., below +6 feet mean lower low water [MLLW]). Field logistics dictated that the flight was conducted in a fixed-wing aircraft on the afternoon of August 28, 2004. Tide at the time was approximately +10 feet MLLW and falling. During the flight, Drs. Houghton and Jewett photographed key areas of interest including port and road sites, unique or important shoreline habitat types, and other features. Despite the generally clear weather, dense smoke from regional forest fires greatly reduced visibility, as well as the quality of the photographs obtained (Photos 12-1 and 12-9). These visibility conditions were present for the duration of the marine sampling in August and September 2004.

Intertidal Studies

Intertidal Habitat Mapping: Under this subtask, mapping of intertidal habitat types present around the IIE was planned, building on the base information expected to be available from the Cook Inlet Regional Citizens Advisory Council (CIRCAC) and the aerial survey. Emphasis was placed on areas of potential project disturbance, specifically the west side of Iniskin Bay and the east side and head (Williamsport area) of Iliamna Bay. The intent of this program was to verify CIRCAC mapping information, provide additional detail to the CIRCAC data, and map any discrepancies using field notes and a hand-held global positioning system (GPS). Because of limited logistical capabilities and poor weather, including many periods of high winds that limited safety for travel by skiff, only limited supplementation of the CIRCAC mapping was possible during the August reconnaissance.

Rocky Intertidal Characterization: Sampling was conducted at the intertidal stations indicated on Figure 12-11. Dominant species were identified along with less numerically abundant but ecologically important "keystone species." Detailed species lists were compiled for each habitat type and elevation and are included in Appendix 12-B.

Key elevations to be sampled quantitatively in rocky intertidal habitat were selected from within the middle of the vertical range of a portion of shoreline with representative assemblages seen to be widespread within that shoreline reach. Two rocky intertidal sites sampled in 1978 and 1996 (Port Site 1 and Scott Island) were resampled at the upper and middle intertidal elevations, and one was also resampled at the lower elevation. In all cases, these stations were resampled, with the help of photographs and previously placed markers, as close as possible to the locations previously sampled. New rocky intertidal sites were established in 2004 near all proposed port sites (Figure 12-11).

At each elevation sampled, a 30-meter transect line was laid out along the tidal-elevation contour line. Along each transect, five to ten 0.25-square-meter quadrats were randomly located or, in the case of previously sampled random quadrats, relocated. In each quadrat, percent cover of all algal species and all sessile animals was first estimated. Then, counts were made of all mobile species larger than about 4 millimeters in size. These data provide a quantitative baseline for comparison with the data available from previous work in IIE and for assessment of potential project impacts.

Intertidal Infaunal and Sediment Collection: In onshore, soft-bottom habitats (sand or mud), stations were established for sampling of infauna (Figure 12-11). Station locations were marked by recording GPS coordinates, placing rebar stakes, or other means (e.g., large boulder) to allow the locations to be found again in future. At each station, five replicate samples were taken with an 80-square-centimer, 15-centimeter-deep hand corer for future analysis of infauna. Once collected, infaunal samples were processed in the field as described under Subtidal Studies, below. The number of samples collected per station is shown in Table 12-3.

At each core location, two 2-centimeter-deep sediment samples were taken from undisturbed sediment adjacent to the core location to form three composite samples: one for analysis of sediment grain size, one for analysis of total organic carbon and total Kjeldahl nitrogen, and one for analysis of metals and petroleum hydrocarbon concentrations. These samples were then packed in coolers and shipped to the laboratory as prescribed in the QAPP (NDM, 2004a).

Tissue Collection: Where larger animals such as clams (*Bivalvia*) or mussels (*Mytilidae*) were observed, specimens were collected for laboratory analysis for baseline trace metals. The animals were counted and identified by species; the date and collection locations were noted; and if applicable, sex, life stage, age, lengths, and weights were recorded. For mussels, because their size was generally small and because they were consistently found at each potential port site, enough animals were collected over a wide geographical area at each station to approximate a 25-gram sample of tissue, as noted in the sampling plan submitted to the Alaska Department of Fish and Game (ADF&G) as part of the Fish Resource Collection Permit application. Since the presumed intent of the ADF&G permit was to allow for the collection of up to 50 mussel samples of 25 grams each, the equivalent of 25 grams each of soft tissue was collected for each tissue sample. These samples were then packaged and shipped to the appropriate laboratory in accordance with the QAPP (NDM, 2004a). A listing of all biological samples is summarized on Table 12-4.

Beach Seining: An important function of the littoral zone is its role as a nursery for juvenile salmonids and other forage fish, as well as for several important invertebrates. While primary littoral use by juvenile salmonids (*Salmonidae*) occurs during the spring, recent work in Knik Arm and in the Aleutian Islands (Houghton, 2004) has shown a substantial presence of these fish in shallow waters along shorelines of embayments and estuaries well into the summer and fall. Beach seining was conducted using a standard 37-meter, fine-mesh seine at the four port-site locations, including three pocket-beaches near Port Site 1b. Seining was conducted along low-gradient, fine-sediment beaches in Iniskin, Iliamna, and Cottonwood bays (Figure 12-12). Catch was identified by species and a representative number (e.g., 20 or more) of each cohort was measured to determine the dominant size classes using this shallow-water habitat at that time.

Subtidal Studies

Subtidal Habitat Characterization: The offshore subtidal areas of the IIE are the least characterized of the marine habitats present. Scuba divers were used to obtain still photography of bottom habitats when visibility and tidal conditions (i.e., slack water) would allow (Photos 12-26 through 12-34). Diver transects were completed in areas of potential project disturbance and areas of ecologically important habitat. Transect locations are shown on Figure 12-13. For each transect, the diver recorded data on biota, substrate type, visibility, tidal conditions, and water depth. A detailed species list was compiled for each transect. These lists are included in Appendix 12-C**.** All water depths are reported in feet below MLLW, otherwise known as zero tidal height. Because these were reconnaissance dives only, the dominant species, in terms of relative biomass or abundance, were targeted for occasional collection for taxonomic purposes. Otherwise, identification of plants and animals was conducted at depth by divers or from photographs.

A lightweight remotely-operated vehicle also was mobilized to collect underwater video footage for habitat characterization; however, currents in the IIE were too strong to operate the remotely-operated vehicle safely and effectively.

Offshore Infaunal and Sediment Collection: Sediment samples were collected with a 0.1-square-meter van Veen grab, focusing on areas of potential project disturbance. Grab samples were collected for laboratory analysis of baseline metals and hydrocarbon concentrations and for infauna analyses. The number of samples collected per station for both intertidal and subtidal infauna and sediment collection is shown in Table 12-3.

TABLE 12-3
Summary of sediment samples collected from Iniskin and Iliamna Bays in August/September 2004

Station	Habitat Type[1]	Number of Sediment Samples Collected[2]					
		Inorganics	BTEX/ GRO	DRO/ RRO	Low-Level Hg	Grain Size	Infauna
Port Site 1	Intertidal	2	2	2	2	2	10
	Subtidal	6	5	5	5	5	5
Port Site 2	Intertidal	2	2	2	2	2	5
	Subtidal	6	5	5	5	5	5
Port Site 3	Intertidal	2	2	2	2	2	10
	Subtidal	0[3]	0[3]	0[3]	0[3]	0[3]	0[3]
Port Site 4	Intertidal	2	2	2	2	2	10
	Subtidal	6	5	5	5	5	5
Port Site Existing (Williamsport)	Intertidal	2	2	2	2	2	10
Blackie Beach	Intertidal	0[4]	0[4]	0[4]	0[4]	1[4]	5[4]
White Gull Island	Subtidal	1[5]	0[5]	0[5]	0[5]	0[5]	0[5]
Offshore of Potential Port	Subtidal	1[6]	1[6]	1[6]	1[6]	1[6]	2[6]
TOTAL		**30**	**26**	**26**	**26**	**27**	**67**

1. Intertidal sediment samples were collected with an 80-cm-square by 15-cm-deep hand corer. Subtidal sediment samples were collected with a 0.1-square-meter van Veen grab.

2. Marine sediment samples were collected and shipped to analytical laboratories for the analyses specified in the 2004 Pebble Project QAPP (NDM, 2004a). Quality assurance/quality control (QA/QC) samples (duplicates, field blanks, trip blanks, etc.) were collected at the frequency specified in the project QAPP; those samples are NOT included in the numbers of sediment samples noted above.

3. Due to the extreme shallow water depths at the subtidal site, the boat equipped with the van Veen grab for collecting bottom sediments could not access the site or its surrounding area; therefore, samples for grain size, infauna, inorganics, and hydrocarbon analyses were not collected in the subtidal environment at this location.

4. Grain size and infauna samples were collected at this site in 2004 for comparison to prior sampling data from the 1970s by Lees et al. (1980) and in 1996 by Pentec (1996) for grain size and infauna. The comparison to historic data sets was the only reason samples were collected; there were no prior trace metals/hydrocarbon data for this site, so samples for contaminant analyses were not collected in 2004.

5. One sample for organics analysis was collected (opportunistically) by a SCUBA diver during a dive transect. This sample was not part of the original sampling plan.

6. This far-field site was added opportunistically while in the field for a cursory comparison to other offshore sites; therefore, the sampling frequency was not as extensive as at planned offshore sampling sites.

BTEX = benzene, toluene, ethylbenzene, and xylenes

GRO = gasoline-range organics

DRO = diesel-range organics

RRO = residual-range organics

The infauna samples were stratified by water depth and, where possible, by substrate type. After collection, infauna samples were processed in the field by washing and sieving them through a 1.0-millimeter-mesh screen. Infauna were then preserved in 10 percent neutral, buffered Formalin solution with 0.1 percent rose-Bengal dye. The preserved samples were transported to the UAF laboratory in

Fairbanks, Alaska. At the laboratory, the samples were transferred from the Formalin solution to a 50 percent isopropyl-alcohol solution for archiving and storage until their analysis.

At each location (Figure 12-14), sediment samples also were collected for analysis for grain size, total organic carbon, total Kjeldahl nitrogen, and trace metal concentrations. In areas where larger infaunas such as clams or polychaetes (*Polychaeta*) were collected, these animals' tissues were submitted for laboratory analysis of baseline trace metals (Table 12-4).

TABLE 12-4
Summary of animals collected for tissue analysis from Iniskin and Iliamna Bays in August 2004

Station	Habitat Type	Date Collected	Common Name (Family or Species)	Sex	Shell (mm)		Fish Length (cm)	Fish Weight (g)	Life Stage[1]	Gear Types[2]	Other Comments
				F/M	Width	Length					
Port Site 1	Middle Intertidal Zone	08/29/04	Horse mussel (*Modiolus modiolus*)						Adult	Hand	1 animal
	Middle Intertidal Zone	08/29/04	Blue mussel (*Mytilus trossulus*)			<<5.0				Hand	~50 mussels to total ~25-50 g of soft tissue
	Subtidal	08/29/04	Helmet crab (*Telmessus cheiragonus*)	M	71	60			Adult	Diver	1 animal
	Subtidal	08/29/04	Snail (*Fusitriton oregonensis*)							Diver	2 animals
	Subtidal	08/29/04	Snail (*Neptunea lyrata*)							Diver	2 animals
	Subtidal	08/29/04	Pacific staghorn sculpin *(Leptocottus armatus)*				8 - 10	70 Total	Juv.	Trawl	6 animals
	Subtidal	08/29/04	Whitespotted greenling (*Hexagrammos stelleri*)				25	~450	Adult	Trawl	1 animal
Port Site 1b	Subtidal	08/31/04	Cockle (*Clinocardium nuttalli*)						Adult	Diver	1 animal
	Subtidal	08/31/04	Pinkneck clam (*Mactromeris polynyma*)						Adult	Diver	1 animal
Port Site 2	Middle Intertidal Zone	08/27/04	Blue Mussel (*Mytilus trossulus*)							Hand	~23 mussels to total ~25-50 g of soft tissue
	Subtidal	08/27/04	Sculpin (*Cottidae*)				24	~450	Adult	HL	1 animal
	Subtidal	08/28/04	Lyre crab (*Hyas lyratus*)	M	61	59			Adult	CPot	1 animal
	Subtidal	08/28/04	Helmet crab (*Telmessus cheiragonus*)	F	49	36			Juv.	CPot	1 animal

Station	Habitat Type	Date Collected	Common Name (Family or Species)	Sex	Shell (mm)		Fish Length (cm)	Fish Weight (g)	Life Stage[1]	Gear Types[2]	Other Comments
				F/M	Width	Length					
Port Site 3	Intertidal	08/30/04	Chum salmon (*Oncorhynchus keta*)	F			63.5	~3,600	Adult	Seine	~100 to 125 g of muscle tissue/liver
	Intertidal	08/31/04	Blue Mussel (*Mytilus trossulus*)						Adult	Hand	18 mussels to total ~25-50 g of soft tissue
	Intertidal	08/31/04	Cockle (*Clinocardium nuttalli*)						Adult	Hand	4 animals
Port Site 4	Middle Intertidal Zone	08/30/04	Blue Mussel (*Mytilus trossulus*)						Adult	Hand	37 mussels to total ~25-50 g of soft tissue
	Lower Intertidal Zone	08/30/04	Clam/bivalve ((*aobliqua*) *Macome oblique)*						Adult/ Juv.	Hand	9 animals
Port Site Existing (Williamsport)	Intertidal	08/31/04	Clam/bivalve (*Mya arenaria*)						Adult/ Juv.	Hand	2 animals

[1] Life Stages: Adult, Juvenile (Juv.), Fry, Larvae

[2] Gear Types: Crab Pot (CPot), Shrimp Pot (SPot), Hook and Line with frozen herring bait purchased in Homer (HL), Seine, Trawl, Diver, Hand

~ = approximately

cm = centimeter(s)

g = gram(s)

mm = millimeters

Offshore Water Sampling: Water samples were collected off each primary port-site location (Figure 12-14). Water samples were collected using a Van Dorn sampler that sampled the water column immediately above the seafloor. A weight was suspended below the sampling device to ensure that the line with Van Dorn attached remained taut and that the sampling device remained vertical in the water column. When sampling, the seafloor was first located with a lead line and then the Van Dorn was lowered to a water depth that ensured the sampler's bottom weight would not touch the bottom, even during choppy sea conditions. As such, it is estimated that the sampling depth corresponded to approximately five to seven feet above the sea floor. Water samples were placed into bottles with laboratory-prepared preservatives and shipped to the project laboratory to determine baseline metals and hydrocarbon concentrations. Sample locations and laboratory analytes are summarized in Table 12-5.

TABLE 12-5
Summary of water samples collected from Iniskin and Iliamna Bays in August/September 2004 (excludes samples collected for field or laboratory quality assurance/quality control purposes)[1]

	Number of Water Samples Collected[1]						
Station	**TSS/Anions**	**BTEX/GRO**	**DRO/RRO**	**Low-Level Hg**	**Ttl/Diss Metals**	**Total Cyanide**	**NH_3**
Port Site 1	1	1	1	1	1	1	1
Port Site 2	1	1	1	1	1	1	1
Port Site 3	1	1	1	1	1	1	1
Port Site 4	1	1	1	1	1	1	1
TOTAL	**4**	**4**	**4**	**4**	**4**	**4**	**4**

1. Marine water samples were collected at depth with a Van Dorn water-bottle sampler and shipped to analytical laboratories for the analyses specified in the 2004 Pebble Project QAPP (NDM, 2004a). QA/QC samples (duplicates, field blanks, trip blanks, etc.) were collected at the frequency specified in the project QAPP; those samples are NOT included in the numbers of water samples noted above.

TSS = total suspended solids

Ttl/Diss = total and dissolved

Offshore Otter Trawling: To sample demersal fish and large invertebrates that may have been missed by other sampling protocols, a 3-meter "try net" was used in soft-bottom, subtidal areas and in flooded, low, intertidal, soft-bottom areas identified during low tides. Catch was identified by species, and a representative number of each cohort (e.g., 20 or more) was measured to identify dominant size classes using this habitat. Selected specimens were also retained for tissue metals analyses (Table 12-4).

12.2.6 Results and Discussion

12.2.6.1 Intertidal Studies

Below is a summary of observations from the 2004 intertidal studies. Detailed observations and maps are provided in Appendices 12-B and 12-D, respectively.

Habitat Mapping

CIRCAC has conducted fairly detailed mapping of the shorelines of Cook Inlet, including the IIE. The data, maps, and shoreline photographs are available on-line at http://imf.geocorte12.net/mapping/cori/launch2.html (CIRCAC and EVOS, 2005). Maps from this database display a variety of shoreline characteristics including dominant morphology, sediment type, and vegetation types. Several of these displays are provided as Appendix 12-D. These maps are reproduced with permission from J. Harper, Coastal & Oceans Resources Inc., and with recognition of the financial contributions of CIRCAC and the *Exxon Valdez* Oil Spill Trustee Council. The following discussion describes shore types and habitats in areas under consideration for port development.

Port Site 1: Port Site 1 is located on the western flank of Knoll Head. The cliff face at Port Site 1 is broken by a series of intertidal arches (Photo 12-2). The terrain at the top to the cliff extends steeply up the flank of Knoll Head. Few trees are present and riparian/upland vegetation consists of grasses, forbs, and shrubs.

Port Site 1a lies along the complex rocky shore east of the entrance to a small rock-bound lagoon at the opening to the large valley (sometimes called the "Y" Valley) between North Head and Knoll Head. At Port Site 1a, the terrain above the cliff is much more gentle leading into the east side of the Y Valley (Photo 12-1). Copses of spruce (*Picea* spp.) and cottonwood (*Populus balsamifera*) are found where pockets of soil have developed. Where sediment exists in pocket-beaches along this reach of shoreline, it is predominantly coarse sand, angular gravel, or cobbles recently broken or eroded from the cliffs or slopes above (Appendix 12-D; Figures 12-D-4 through 12-D-6).

Port Site 1b is similar in substrate and vegetation to Port Site 1a. It is located north of Port Site 1, just south of the newly installed weather station. In the middle of the coarse-sand, angular-gravel beach that comprises Port Site 1b is a tall, oblong, angular rock. The small embayment is subject to heavy wave action, refracting off of the headland on the north end of the beach.

The CIRCAC mapping classified this shoreline morphology as "rock and sediment," (Appendix 12-D; Figures 12-D-1 through 12-D-3) which reflects the mix of rocky cliffs, outcrops, sea stacks, and reefs interspersed with small areas of sand, gravel, or cobble pocket-beaches (Photo 12-1). Near vertical cliffs extend upward from the upper tidal elevations at Port Site 1a and the mid-tidal elevations at Port Site 1.

In keeping with the coarse sediment types, CIRCAC reported no eelgrass (*Zostera marina*) in this vicinity (Appendix 12-D; Figures 12-D-7 and 12-D-8) and none is expected.

Port Site 2: CIRCAC classified the area around Port Site 2 as having a rock and sediment morphology similar to Port Site 1. While the nature of the upper shoreline (Appendix 12-D; Figure 12-D-2) is similar to that at Port Site 1, the habitat provided by the entire intertidal zone is very different from that at Port Site 1. The upper beach is still a rock cliff at the top of which a steep slope ascends the east side of Knoll Head (Photo 12-3). However, field visits show that the toe of the cliff is in the upper-middle tide range (about +6 to +8 feet MLLW), below which a rocky/shingle beach, no doubt formed by rocks falling from the cliff and mountain above, extends down to about +2 to +3 feet MLLW. A mud flat (Photo 12-4) begins at this elevation and extends essentially east and north, occupying a great majority of inner Iniskin Bay.

The CIRCAC mapping indicates that patchy eelgrass begins just north of the Port Site 2 area and continues north along much of the west side of Iniskin Bay (Appendix 12-D; Figure 12-D-8). The field survey at Port Site 2 documented scattered individual eelgrass blades.

Port Site 3: Port Site 3 is at the base of Diamond Point at the north entrance to Cottonwood Bay from Iliamna Bay. The shoreline here is also classified by CIRCAC as rock and sediment (Appendix 12-D; Figure 12-D-1) and in that regard is somewhat similar to Port Site 2. A rather extensive rock buttress projects into the intertidal zone from the base of a high cliff at the face of Diamond Point (Photo 12-5). At the base of this rock habitat, at about -2 feet MLLW, a sand flat extends to the west into Cottonwood Bay and to the north into Iliamna Bay.

The CIRCAC mapping did not record eelgrass in the immediate area (Appendix 12-D; Figure 12-D-7); however, substantial patches of eelgrass were identified during the 2004 reconnaissance on the Cottonwood Bay side of Diamond Point.

Port Site 4: The CIRCAC mapping identifies the area around Port Site 4 as including both a sediment geomorphic type flanked on either side by rock and sediment geomorphology (Appendix 12-D; Figure 12-D-1). Sediment type here is described as sand and gravel in the CIRCAC maps (Appendix 12-D; Figure 12-D-4), but based on observations during the 2004 reconnaissance, appears to be more complex. At the upper elevation in a south-facing bight on the west side of North Head, an arcuate pocket-beach of pebble-sized gravel is contained to the west by a rocky outcrop (Photo 12-6) and to the east by a steep rocky face on the west side of a small peninsula forming the east entrance to Iliamna Bay. The lower beach sediment is a mix of cobbles and boulders in a sand matrix. Eelgrass is not present (Appendix 12-D; Figure 12-D-7).

Blackie Beach: Blackie Beach lies in an area described by CIRCAC as having a sediment morphology type (Appendix 12-D; Figure 12-D-2). Sediment type is mapped as sand (Appendix 12-D; Figure 12-D-5). This is consistent with the nature of the broad lower tidal flat below about MLLW (Photo 12-7) observed during the 2004 reconnaissance. However, the steeper beach above MLLW is more accurately described as consisting of pebble and granule-sized gravels.

Eelgrass was not mapped here by CIRCAC (Appendix 12-D; Figure 12-D-7) and was only very sparsely present in 2004. At the time of the 1996 surveys, patches of eelgrass were quite prominent on the sand flat with over 20 percent cover in June 1996 (Pentec, 1996).

Scott Island: The south side of Scott Island is justifiably considered to be of a rocky morphology (Appendix 12-D; Figure 12-D-2), although small pockets of coarse pebble/granule sediment are also present. No eelgrass is present in this very exposed site (Photo 12-8).

Iliamna Bay: The portion of Iliamna Bay north of Diamond Point to Williamsport is occupied by a broad mudflat that reaches across the bay at low tide except for a meandering central drainage channel. The CIRCAC mapping identifies this as sedimentary (Appendix 12-D; Figure 12-D-1) with the dominant sediment type as mud (Appendix 12-D; Figure 12-D-4). In actuality, the broad mudflat is bordered near the high-tide line by rock rubble and bedrock outcrops (Photo 12-9).

Eelgrass is reported as patchy along much of the west side of the bay and along a portion of the east side (Appendix 12-D; Figure 12-D-7). Eelgrass occurrence along the northwest shoreline was confirmed in 2004.

Intertidal Ecology

Intertidal surveys of rocky and soft substrate habitats were conducted between August 27 and September 1, 2004. Waters along the shoreline during these surveys ranged narrowly in salinity between 28.0 and 28.4 parts per thousand, and in temperature and between 12.6 and 13.3 degrees Celsius.

Rocky Habitats: The results of the rocky habitat surveys are summarized below and are presented in detail with data tables and figures in Appendix 12-B.

- **Port Site 1 (Knoll Head)**—This site lies on a low bedrock reef projecting seaward in front of the vertical cliffs that lie at the base of Knoll Head. The rock substrate was dominated by brown algae and red algae and had a mean algal cover (all species) of nearly 90 percent (Table 12B-1). The kelps formed an overstory above many species of smaller red algae. Animals were typically sparse and consisted of small snails (*Gastropoda*), newly set barnacles (*Cirripedia*), and scavenging hermit crabs (*Paguridae*).

- **Port Site 1a (Knoll Head West)**—The site lies among rocky benches and headlands approximately midway between Knoll Head and the entrance to the lagoon between Knoll Head and North Head. The upper elevation at Knoll Head is located on top of a low exposed ridge where pockets in the rock form small tide pools. The dominant species for all years sampled (i.e., 1978, 1996, and 2004) was the rockweed *Fucus gardneri*. Sessile animals (mostly barnacles of the genus *Balanus, Semibalanus*, and *Chthamalus*) and motile littorine snails (*Littorina sitkana*), limpets (Lottiidae, genus *Lottia*), hermit crabs, and the drill (*Nucella lima)* were also present (Table 12B-2). Several species that were common in 1996 (e.g., the pulmonate gastropod *Siphonaria thersites*, the drill *Buccinum baeri*, and the sea star *Leptasterias hexactis*) were not present in 2004.

  The middle elevation at Port Site 1a lies on the crest of a low bedrock ridge. From 1978 and 1996 to 2004, this site showed a dramatic shift in algal dominance from red algae (Rhodophyta) to brown algae (rockweed, genus *Fucus*). Few animals were present at this elevation in 2004.

  The lowest elevation at Port Site 1a consists of a mosaic of bedrock ridges, tide pools, and boulders and consequently supports a much greater diversity of plants and animals than at higher elevations. A variety of snails, sea stars, and crustaceans occurred in this rocky habitat while sediment pockets in tide pools included a number of large clams (deposit feeders and filter feeders), polychaetes, and the burrowing spoon worm (*Echiurus echiurus)*.

- **Port Site 2 (SW Iniskin Bay)**—The shoreline at Port Site 2 is a mix of rock fall and bedrock at mid and upper intertidal elevations and fine mud at lower elevations. The periwinkle snail (*L. sitkana)* and limpets were abundant on the upper rocks at this site. The barnacle *Semibalanus balanoides* was abundant at high elevations, and the drill (*Nucella)* was abundant at middle elevations (Table 12B-3). Algae were not very abundant. Isolated patches of mussels (*Mytilus trossulus*) were present mostly in protected crevices. The only low-elevation rock at this site was

in scattered boulders out on the mudflat; these boulders supported barnacles (*Balanus, Semibalanus)* and a few limpets, hermit crabs, mussels, and algae.

- **Port Site 3 (Diamond Point)**—This site is located on a rocky bench at the north entrance to Cottonwood Bay. The mid elevations had abundant algae (*Fucus;* rockweed) and high coverage of barnacles (*Balanus* spp., over 40 percent; Table 12B-4). Periwinkles (*Littorina sitkana*), limpets (Lottidae), and drills (*Nucella)* were also present. Rockweed (*Fucus*) was moderately abundant at low elevations with barnacles occupying nearly 20 percent of that substrate. The lower elevation at Diamond Point was relatively poorly vegetated, and kelps, which typically are dominant on lower-elevation rock, were largely absent.

- **Port Site 4 (North Head)**—The site is located in a small bight on the west side of North Head. The upper elevations consist of pocket-sized gravel contained to the west by a rocky outcrop. General observations at Port Site 4 noted a high cover (to 80 percent) of barnacles while rock crevices contained mussels, drills, limpets, and sea stars. The middle and lower elevations consist of a boulder-cobble substrate set in a sandy matrix. Rockweed dominated at both elevations, but red algae and kelps were increasingly important at the lower elevation sampled (Table 12B-5). Animal cover on rock surfaces was low at the mid elevation but higher at low elevations. In the low-elevation sandy matrix, bivalves (*Macoma* sp.), polychaete (*Nephtys* sp.), and a gunnel (*Pholidae*) were observed outside of the established transect.

- **Scott Island**—This site was included in the reconnaissance study as a potential reference site. The upper and mid elevations showed increased algal cover in 2004 relative to 1996, especially for rockweed. The same shift in dominance from red algae to rockweed seen at Knoll Head West was evident at the middle elevation. Motile animals increased in 2004 and were strongly dominated by the periwinkle (*Littorina*; Table 12B-6). Cover of rock substrate by sessile animals was low in all years. Herring (*Clupea harengus*) eggs were found on the red algae at this site in June 1996. The lower elevations crossed a low, rocky swale with a broad, shallow tide pool. Total algal cover was high in 2004 but was considerably higher in 1996 and could have been a function of the time of sampling. In all years, the low-elevation station was dominated by kelp (especially *Laminaria* sp.*)*. Red algae (*Palmaria* spp.*)* and the green alga *Ulva* spp. were also common in all years. Motile species were not abundant in any year but the small snail *Lacuna* sp. showed increases in 2004.

  During low tide (-2 feet MLLW), small schools of both juvenile and adult Pacific sand lance (*Ammodytes hexapterus*) and several adult greenling (*Hexagrammos* sp.**)** were seen in larger tide pools and areas off the rocky benches at Scott Island.

Soft (Gravel, Sand, Mud) Habitats: A brief summary of the soft substrate habitats and sampling locations follows.

- **Port Site 1a (Knoll Head)**—Only small pockets of gravel or sand habitat are found on the basically rocky intertidal substrates at Port Site 1. Infauna and chemistry samples were taken from a small pocket of sand and gravel east of the rocky site described above. Elevation was approximately -2 feet MLLW.

- **Port Site 2 (SW Iniskin Bay)**—Mid-elevation infauna and chemistry samples were taken at the break between the mudflat and rocky middle elevation described above. Lower-elevation samples were taken on the broad mudflat at a tidal elevation of approximately -0.5 feet MLLW (Photo 12-4).

  The mudflat at Port Site 2 is relatively uniform in substrate and texture with an occasional patch of a few eelgrass shoots. The mudflat slopes very gradually toward the central channel of Iniskin Bay to the east. Few organisms were present on the sediment surface except in the vicinity of a few large widely-scattered boulders (see above). The mud surface had scattered holes presumably made by polychaetes, the bivalve *Mya* spp., and the spoonworm *Echiurus*. Macroalgae was composed of scattered plants of the kelp *Laminaria saccharina* and the green alga *Ulva* spp.

- **Port Site 3 (Cottonwood North Entrance)**—Infauna and chemistry samples were taken about mid-way along the face of the beach that arcs northwest into Cottonwood Bay from Diamond Point (Figure 12-11). Mid-elevation samples were taken from the upper mud and sand flat, just below the break in slope (about +1 foot MLLW) from the moderately sloping mid and upper sandy-gravel beach. A single excavation of about 1/16 square meter in this area yielded seven *Echiurus*, three polychaetes (*Nephtys* sp.), and one bivalve (*Mya* sp.)

  Lower-elevation chemistry and infaunal samples were taken in a soft mud ridge at the lower elevation (about -1 foot MLLW) on the broad flat (Photo 12-22) that extends west into Cottonwood Bay from the rocky sampling site at Diamond Point. The flat includes a mix of relatively firm and relatively soft mud and sand with standing water over much of the surface at low tide and many drainage channels. The flatter and firmer areas with standing water supported substantial patches of eelgrass. Macroalgae on the occasional cobble or boulder included the green algae *Ulva* sp., *Enteromorpha linza*, and *E. intestinalis;* the kelp *Laminaria* sp.; tufts of filamentous red algae; and the saccate red alga *Halosaccion firma*. Also on the boulders were the green sponge *Halichondria panacea*, along with mussels, barnacles (*S. balanoides*), and their predator, the drill *N. lima*. Other macrofauna noted or indicated in the soft sediments during the survey included fecal mounds indicative of the polychaete *Abarenicola pacifica* and siphon holes of the clam *Mya*. Also seen were numerous nemerteans (*Paranemertes peringrina*), hairy hermit crabs, and in shallow surface water, small cottid fish (Cottidae), probably *Clinocottus acuticeps*.

- **Port Site 4 (North Head)**—Infauna and chemistry samples (Figure 12-11) were taken at two elevations on a low, boulder-strewn sand flat below and south of the area sampled for epibiota. The higher of the two elevations was at about MLLW, just below the break in the gradient between the upper, more steeply sloping gravel beach and the lower boulder-strewn sand flat (Photo 12-23). The lower set of samples was taken at about -2 feet MLLW. Both sets of samples were taken in silty sand with an anoxic layer beginning at about 5 centimeters below the sediment surface.

- **Port Site Existing (Williamsport area)**—The inner (northern) portions of Iliamna Bay consist of a continuation of the large mudflats that extend northward up the bay beginning at Diamond Point. At low tide, the majority of these flats are exposed, save for a drainage channel that carries the outflow from the several fresh-water streams entering the bay. In general this channel is east of the centerline of the bay. Very small patches of eelgrass were seen widely scattered over the

inner third of this area during the August 2004 survey, and patchy eelgrass is reported in the area by the CIRCAC habitat surveys (Appendix 12-D, Figure 12-D-7; Photo 12-24).

- **Blackie Beach**—Blackie Beach lies in a bight, semi-protected by Scott Island and the Mushroom Islets, on the northern entrance to Iniskin Bay (Figure 12-11; Photo 12-7). This beach was sampled in the 1970s by Lees et al. (1980) and in 1996 by Pentec (1996). The upper beach is a relatively long and uniform sand and gravel beach that transitions into a very broad and firm sand flat at about MLLW. The location sampled in 2004 was located as near as possible to the location sampled in previous work (with the aid of photographs) and lies at about -0.5 feet MLLW.

  In 1996, eelgrass coverage measured 21.4 percent at this station—a sharp contrast to the less than 1 percent cover seen in 2004. There was considerable evidence of recent erosion on this beach with remaining patches of eelgrass elevated above the surrounding beach and many dead articulated *Mya* shells still oriented vertically at the sediment surface.

Table 12-4 lists the number of animals collected for trace metals analyses in both intertidal and subtidal habitats, with pertinent data recorded for each species collected. The equivalent of four to eight mussel samples (25 grams of soft tissue each) was collected at each of the four port-site alternatives, and a single *Modiolus* mussel also was collected. The mussel *Mytilus* currently appears to be a good candidate for additional follow-on sampling. The results of the analyses of the infauna and sediment samples will be presented at a later time.

Pelagic and Demersal Fish and Invertebrates: Beach seining was conducted at six different beaches in late August 2004 between Port Sites 1 and 2 (three locations), at Port Site 3 (inside Diamond Point), at Port Site 4 (North Head), and at Port Site Existing (existing port) near Williamsport. Although the intent of this methodology was to make two sets at each site sampled, the very large numbers of juvenile Pacific herring (Photo 12-25) encountered at several sites caused us to make only a single set at those locations. Intertidal habitats sampled during beach seine activities in 2004 were composed of low- to moderate-gradient sand or gravel beaches. Most seining took place at higher tidal elevations. A summary of beach seine catch is presented in Table 12-6.

- **Port Site 1b (Knoll Head East)**—Intertidal habitats in the area of Knoll Head were largely composed of rocky beaches unsuited to the use of a beach seine (Photos 12-1 and 12-2). However, several pocket-beaches composed of sandy substrates were interspersed among the rocky headlands on the east side of Knoll Head. Beach seine sets were made at three beaches located between Port Sites 1 and 2 and were collectively referred to as Port Site 1b (Figure 12-12). Fish data for the three beaches were composited.

  Larval and juvenile stages of two forage-fish species (Pacific herring and Pacific sand lance) dominated catch at Port Site 1b (Table 12-6). Pacific herring were most abundant, comprising 68.4 percent of catch.

TABLE 12-6
Summary of fish collected by beach seine from Iniskin and Iliamna Bays during August 2004

	TOTALS			PS1B			PS3			PS4			PSE		
	Catch	**CPUE**	**Mean Length (mm)**	**Catch**	**CPUE**	**Mean Length (mm)**	**Catch**	**CPUE**	**Mean Length (mm)**	**Catch**	**CPUE**	**Mean Length (mm)**	**Catch**	**CPUE**	**Mean Length (mm)**
Chum Salmon* (*Oncorhynchus keta)*	16	2.29	—	0	0.00	—	16	8	—	0	0	—	0	0	—
Pink Salmon* (*Oncorhynchus gorbuscha*)	2	0.29	—	0	0.00	—	2	1	—	0	0	—	0	0	—
Dolly Varden (*Salvelinus malma*)	1	0.14	148	1	0.33	148	0	0	—	0	0	—	0	0	—
Saffron Cod (*Eliginus gracilis*)	1	0.14	137	0	0.00	—	1	0.5	137	0	0	—	0	0	—
Pacific Herring *(Clupea harengus)*	2998	428.29	42.09	312	104.00	39.8	191	95.5	—	1517	1517	38.23	978	978	48.39
Pacific Sand Lance (*Ammodytes hexapterus*)	141	20.14	59	141	47.00	59	0	0	—	0	0	—	0	0	—
Sculpin (Cottidae)	38	5.43	78.4	2	0.67	99.5	1	1	68	0	0	—	34	34	57
Surf Smelt *(Hypomesus pretiosus*)	1	0.14	118	0	0.00	—	0	0	—	0	0	—	1	1	118
Starry Flounder *(Platichthyes stellatus)*	2	0.29	156.5	0	0.00	—	0	0	—	0	0	—	2	2	156.5
Tubesnout *(Aulorhynchus flavidus*)	0	0.00	—	0	0	—	1	0.5	70	0	0	—	0	0	—
Total	**3200**	**457.14**	**50.03**	**456**	**152.00**	**47.27**	**211**	**106.5**	**81.6**	**1517**	**1517**	**38.23**	**1015**	**1015**	**57.59**

* All salmon were adults

CPUE = catch-per-unit-effort

— = measurements not taken

Length-frequency data (Figure 12-15) suggest a single year-class of herring. Two indistinct size distributions were apparent in catches at Port Site 1b and at Williamsport, but only the smaller of these cohorts was present at Port Site 4 (Figure 12-7). In the field, these two size distributions also were observed. Herring between 30 and 40 millimeters in length were elongate and transparent; however, fish over about 45 millimeters took on the more typical color and shape of adults. Herring-spawning surveys conducted by ADF&G indicate that spawning occurs in the area over a relatively long period between late April and early June (Otis, pers. comm., 2004), which likely accounts for the wide size distribution of young-of-the-year fish.

Pacific sand lance were second in abundance, comprising 31 percent of all fish caught at Port Site 1b (Table 12-6). All sand lance observed were transparent young-of-the-year, were relatively uniform in size, and measured between 58 and 63 millimeters (Figure 12-15). No older juveniles or adult Pacific sand lance were captured in beach seine sets.

Catch-per-unit-effort (CPUE), defined as the number of fish caught per beach seine set, shows a moderately abundant use of the beaches between Port Site 1 and Port Site 2 by juvenile forage fish. The CPUE for individual species ranged from 104 fish per set for herring to 47 fish per set for Pacific sand lance (Table 12-6).

One juvenile Dolly Varden char (*Salvelinus malma*) and two sculpin (Cottidae) were the only other fish captured during beach seining in this area (Table 12-6).

- **Port Site 3**—Juvenile Pacific herring dominated catches at Port Site 3, comprising 90 percent of all fish captured in beach seine sets at the site. Individual measurements were not taken of herring at Port Site 3, but fish were observed to be of similar size to those observed at Port Site 1b. The CPUE for herring was also similar to that observed at Port Site 1b (95.5 at Port Site 3 compared with 104.0 at Port Site 1a); however, Pacific sand lance were not encountered at Port Site 3 (Table 12-6).

  In the second set made at Port Site 3, 16 adult chum salmon (*Oncorhynchus keta*) and two adult pink salmon (*O. gorbuscha*) were captured (Table 12-6). Measurements were not taken, but approximate lengths ranged from 550 to 750 millimeters. Schools of adult salmon were rolling at the surface throughout the nearshore of Port Site 3 and periodically moved within reach of the beach seine. Two small streams discharge in the vicinity of Port Site 3, and adult salmon were likely staging in the nearshore before migrating up the streams on spawning runs.

  One sculpin, a saffron cod (*Eleginus gracilis*)), and a tubesnout (*Aulorhynchus flavidus*) were the only other species observed in beach seine sets at Port Site 3 (Table 12-6).

- **Port Site 4**—Juvenile Pacific herring was the only species captured in the single beach seine set made at Port Site 4. Herring were very abundant at this site with over 1,500 individuals captured in the one set. The CPUE for herring was six to eight times that of Port Site 1b or Port Site 3 (Table 12-6). Length-frequency data (Figure 12-16) show a widely distributed size range of young-of-the-year herring similar to that found at Port Site 1b (Figure 12-15). The same physical differences between younger and older fish also were observed at this site, as discussed above.

- **Port Site Existing (Williamsport)—**As at Port Site 4, numerous juvenile herring (978) were observed in one beach seine set conducted at a beach just south of the entrance to Williamsport (Table 12-6). The mean fish size was larger at Port Site 4, and length-frequency data suggest the presence of an additional cohort (Figure 12-17). Young-of-the-year fish ranged from 31 to 55 millimeters, as found at the other sites. Another, older year class may also be present; these larger fish ranged from 70 to 90 millimeter fork length. These larger herring were not observed at the other beach seine sites.

  A moderate number of sculpins also were observed at Port Site Existing (Table 12-6). All individual sculpins were not positively identified in the field, but most were Pacific staghorn sculpin (*Leptocottus armatus*). Representative samples collected for laboratory identification indicated that two additional species, buffalo sculpin (*Enophrys bison*) and great sculpin (*Myoxocephalus polyacanthocephalus*), also were present. One surf smelt (*Hypomesus pretiosus)* and two starry flounder (*Platichthys stellatus*) were the only other species observed in the beach seine set at Port Site Existing.

12.2.6.2 Subtidal Studies

Subtidal studies consisted of diver transects, van Veen grab sampling of sediments, Van Dorn water-bottle sampling, and offshore bottom trawling.

Subtidal Diver Transects

To conduct subtidal habitat characterization, six diver transects were completed at Port Sites 1, 2, and 4 and at White Gull Island (Figure 12-13) during the last three days of August 2004. No diver transects were conducted in the vicinity of Port Site 3 due to shallow depth, fine mud substrate, and limited in-water visibility (generally less than 1 foot)**.** Transects in the IIE were typically oriented either perpendicular to or parallel to shore. The results of the surveys are briefly summarized below and are presented in detail in Appendix 12-C (also see Photos 12-26 through 12-34).

Port Site 1: Two transects were conducted on August 29 at Port Site 1. The first ran for almost 800 feet perpendicular to shore at tidally-adjusted water depths of 11.2 feet to 49.6 feet below MLLW**.** Sea stars of the genus *Leptasterias* were the dominant epifaunal organisms and occurred on mixed sand/gravel/cobble substrates near shore and on mostly gravel substrates at the deepest end of the transect. Other animals abundant at the site included dense mats of tubiculous suspension-feeding sabellid polychaetes (Photo 12-26), presumably *Schizobranchia insignis*. Hermit crabs (*Elassochirus* spp., *Pagurus beringanus*; Photos 12-27 and 12-28), and sea stars (*Crossaster papposus, Henricia leviuscula)* were also quite abundant.

The second transect at Port Site 1 ran 437 feet and was conducted parallel to shore at 15.2 to 16.9 feet below MLLW (with the southern terminus of the transect being approximately Entrance Rock). Mats of tubeworms (*S. insignis*?, Photo 12-26) occurred patchily on a gravel substrate. Other common animals present were rock jingles (*Pododesmus macroschisma*), chitons (*Tonicella lineata*, *T. insignis*, and *Mopalia ciliata*) and crabs (*Pagurus* sp., *Cancer oregonensis, Hyas lyratus, and Pugettia gracilus*).

Port Site 1b (midway between Port Site 1 and 2): The diver transect midway between Port Site 1 and 2 was conducted for almost 675 feet very near shore between 1.6 feet above MLLW to 10.8 feet below MLLW. The sponge *Superites* sp. was the most abundant organism present on a mixture of substrates

from sand/silt to gravel and boulders. Patchy mats of what appear to be tubeworms (*S. insignis*?; Photo 12-26), hermit crabs (*Pagurus;* Photos 12-27 and 12-28), blue mussel (*Mytilus edulis)*, pinkneck clam (*Spisula polynyma*) or Arctic surfclam (*Mactromerus polynyma*), and the cockle *Clinocardium nuttalli* also were present. Divers experienced very strong currents on this transect during a flooding tide.

Port Site 2: The diver transect at Port Site 2 was conducted for 307 feet, running perpendicular to shore at 10.6 feet to 33.5 feet below MLLW. This was the shortest diver transect because visibility at deeper than 20 feet was too limited to adequately characterize the transect any deeper. Divers had difficulty even seeing their gauges below 20 feet. Due to poor visibility (1 to 2 feet), only barnacles (*Balanus* sp.) and bryozoans (*Flustrellidae*) were observed on sandy gravel substrate**.**

Port Site 4: The transect at Port Site 4 (North Head) ran from 7.8 feet to 19.6 feet below MLLW (Photos 12-29, 12-30, and 12-31). Numerous nudibranchs (*Hermissenda crassicornis*) occurred on sandy substrate with boulders interspersed nearshore and on a sandy/silt bottom at deeper depths. Other animals prevalent at this location were sea stars (*Leptasterias* spp. and *Henricia leviuscula*) and polychaetes (*S. insignis?* and *Potamilla* sp.). This transect was more than 1,200 feet long and was the longest of the transects conducted in the IIE in August 2004.

White Gull Island: The diver transect conducted near White Gull Island was more than 400 feet long and occurred from 3.5 feet to 27.3 feet below MLLW (Photos 12-32, 12-33, and 12-34). The shallowest end of the transect was in boulders that transitioned to gravel substrate at deeper depths. Animal and algal diversity was high, with several species being very abundant. These included brown algae (*Alaria*, *Agarum*, and *Laminaria*), sea stars (*Leptasterias* spp. and *Henricia leviuscula*), the brittle star *Ophiopholus aculeata,* chitons (*Mopalia ciliata, Tonicella lineata*, and *T. insignis*), the nudibranch *Onchidoris bilamellata,* and the hermit crab *Pagurus beringanus*.

Offshore Bottom Trawls

Two, 5-minute bottom trawls using a research try-net were made in littoral mudflat habitats off Port Site 1 and Port Site 2 on August 29, 2004. Several demersal fish were captured, dominated by several species of flatfish. Most of these fish were captured while trawling at Port Site 2 (Table 12-7). Specifics about each trawling event are presented below.

Port Site 1: Only one juvenile starry flounder was captured at the trawl transect off Port Site 1 (Table 12-7). It is not known why so few fish were captured; however, only one tow was conducted at Port Site 1 because of deteriorating weather conditions. It is possible that the increased swells experienced during this tow made it difficult to keep the trawl in contact with the bottom.

Port Site 2: Demersal fish composition at Port Site 2 was dominated by yellowfin sole, starry flounder, and Pacific staghorn sculpin (Table 12-7). Length-frequencies indicate that all were juvenile stages (Figure 12-18), although the sample size was not sufficient to determine how many year classes were present. Other flatfish species, Alaska plaice (*Pleuronectes quadrituberculatus*), southern rock sole (*Lepidopsetta bilineata*), and sand sole (*Psettichthys melanostictus*), along with saffron cod, were captured in lower numbers. Also notable in trawl transects at Port Site 2, was the capture of numerous—too numerous to count—shrimp in the family Crangonidae. Most of these appeared to be juveniles. Five hermit crabs, *Pagurus ochotensis,* were also captured in trawls at Port Site 2.

TABLE 12-7
Summary of fish and invertebrates collected by trawl from Iniskin and Iliamna Bays in August 2004

	TOTALS			PORT SITE 1			PORT SITE 2		
	Catch	**CPUE**	**Mean Length (mm)**	**Catch**	**CPUE**	**Mean Length (mm)**	**Catch**	**CPUE**	**Mean Length (mm)**
Alaska Plaice (*Pleuronectes quadrituberculatus*)	1	0.33	43	0	0	—	1	0.5	43
Pacific Cod (*Gadus macrocephalus*)	1	0.33	76	0	0	—	1	0.5	76
Hermit Crab (*Pagurus ochotensis)*	5	1.67	0	0	0	—	5	2.5	0
Rock Sole *(Lepidopsetta bilineata)*	4	1.33	77.5	0	0	—	4	2	77.5
Saffron Cod (*Eleginus gracilis*)	2	0.67	118.5	0	0	—	2	1	118.5
Sand Sole (*Psettichthys melanostictus*)	1	0.33	156	0	0	—	1	0.5	156
Sculpin (Cottidae)	10	3.33	106.9	0	0	—	10	5	106.9
Smelt (Osmeridae)	1	0.33	90	0	0	—	1	0.5	90
Starry Flounder (*Platichthys stellatus*)	9	3	70.6	1	1	100	8	4	70.6
Yellowfin Sole (*Limanda aspera*)	10	3.33	94.1	0	0	—	10	5	94.1
Shrimp (Crangonidae)	TMTC	—	—	0	0	—	TMTC	—	—
Total	**44**	**14.67**	**91.21**	**1**	**1**	**100**	**43**	**21.5**	**91.21**

TMTC = Too many to count

12.2.6.3 Tissue, Sediment, and Water-Chemistry Samples

Table 12-4 lists the number of animals collected for tissue analyses of trace metals from both intertidal and subtidal habitats. Data were recorded for each species collected, including the date and sampling locations, gear type, and if applicable, sex, life stage, age, and lengths and weights. Sediment and water samples collected in 2004 for metals and hydrocarbon analyses are summarized by station in Tables 12-3 and 12-5, respectively.

The results of these analyses and analysis of the data will be presented at a later time.

12.2.7 Summary

This component of the overall Pebble Project baseline studies investigated marine habitat and species of the IIE that may be impacted by project marine-transportation alternatives. This work built on data that

had been gathered in studies during the 1970s under the OCSEAP Program along with other investigations in lower Cook Inlet. Conditions encountered and data gathered during a single field survey conducted in late August and early September 2004 are reported.

Sediment and infauna samples were collected at six intertidal stations and six subtidal stations in the IIE in August/September 2004. This sampling included 35 sediment samples collected for inorganic analyses, 26 samples for organics, 26 samples for low level mercury, 27 sediment samples for grain size characteristics, and 67 samples for infauna analyses. At-depth water samples were also collected at four subtidal stations for a number of analyses including total suspended solids, organics, and inorganic compounds. The results of the laboratory analyses of these samples, as well as tissue sample analyses, will be reported at a future date.

12.2.7.1 Intertidal Ecology

Mapping conducted by CIRCAC (Appendix 12-D) provides a good general characterization of dominant geomorphology, substrate type, and vegetation of shorelines around the IIE. However, field reconnaissance and mapping is necessary to fully understand the fine-scale characteristics of a specific site, especially where the nature of the habitat changes from upper to lower intertidal elevation.

At stations sampled sporadically over the last 28 years in the IIE, intertidal conditions had not changed dramatically except for the apparent shift in algal dominance at rocky middle intertidal stations. At these locations, the dominant algae have shifted from the red algae *Palmaria* spp.—which are capable of recolonizing rapidly (e.g., from remnant holdfasts) following physical abrasion such as ice scour—to rockweed, a perennial species that requires a few years without disturbance to reach maturity. This shift suggests that conditions in recent years may have been more benign than in the previous few decades.

Other differences in intertidal dominance between previous years and 2004 may have been the result of the difference in time of year when sampling occurred. Certainly, that explains the presence of herring spawn at the middle and lower elevations on Scott Island in June 1996, and their absence in 2004.

Generally, the intertidal areas sampled represent a wide range of habitat types from bedrock to mudflat. Each supports a distinct biota of resident organisms. Each also provides feeding areas for pelagic and demersal fish and invertebrates that forage over the intertidal zone during high tides. Included in this category is estuarine and nearshore rearing of juvenile salmonids, especially pink and chum salmon which outmigrate from streams along the IIE shoreline, although no juveniles of these species were found in late August 2004 beach seining.

A gradient of decreasing diversity of both plants and animals was evident along the gradient of declining wave exposure and salinity and increasing suspended-sediment load among the rocky stations. Scott Island and Knoll Head, being the most exposed, had the greatest diversity of algae with Knoll Head West only slightly less diverse. Iniskin Bay (Port Site 2) and North Head (Port Site 4) were intermediate in exposure and richness, while Diamond Point had the least diverse biota, reflecting its semi-protected location and the influence of high suspended-sediment loads from Iliamna Bay.

Another important ecological function of intertidal habitat is as a substrate for spawning by Pacific herring (as evidenced by ADF&G data and by limited observations at Scott Island in 1996). Also, rearing

of larval and juvenile herring resulting from that spawning is clearly important along IIE shorelines as indicated by 2004 beach seining.

12.2.7.2 Subtidal Studies

The six qualitative reconnaissance dives in the IIE nearshore region were performed to survey the habitats and benthic assemblages in areas of interest. In general, the water visibility was limited, often less than six feet, due to high turbidity.

For the diver transects that were oriented perpendicular to shore, the substrate generally graded from coarsest nearshore to finest offshore, with a mixture throughout. Fauna at the shallowest depths tended to be relatively sparse, presumably due to occasional scouring by ice. Brown algae (kelp) were mainly prevalent closest to shore at Port Site 4 and White Gull Island, but also at Port Site 1b in relatively low density.

Dominant macroinvertebrates on soft subtidal substrates were mainly the tube-dwelling sabellid polychaete *S. insignis*(?). Dense mats of this suspension-feeding worm were also present in the IIE area in the 1970s (Lees et al., 1980).

Because coarse substrates predominated on most diver transects, invertebrate fauna were dominated by attached and mobile organisms. Common attached invertebrates included sponges, hydroids, sea anemones, the rock jingle, and bryozoans. Common mobile invertebrates included several species of snails, chitons, nudibranchs, crabs, and sea stars.

Demersal fishes were few on diver transects, while the whitespotted greenling and unidentified juvenile flatfishes were most common. All of the common plants, invertebrates, and fishes seen in 2004 were also prevalent in dive surveys in the IIE area in the 1970s (Lees et al., 1980).

Limited trawl sampling indicates that the vast mudflats in Iniskin and Iliamna bays provide important rearing habitat for a variety of demersal fish, especially flatfish, cottids, and gadids.

12.3 References

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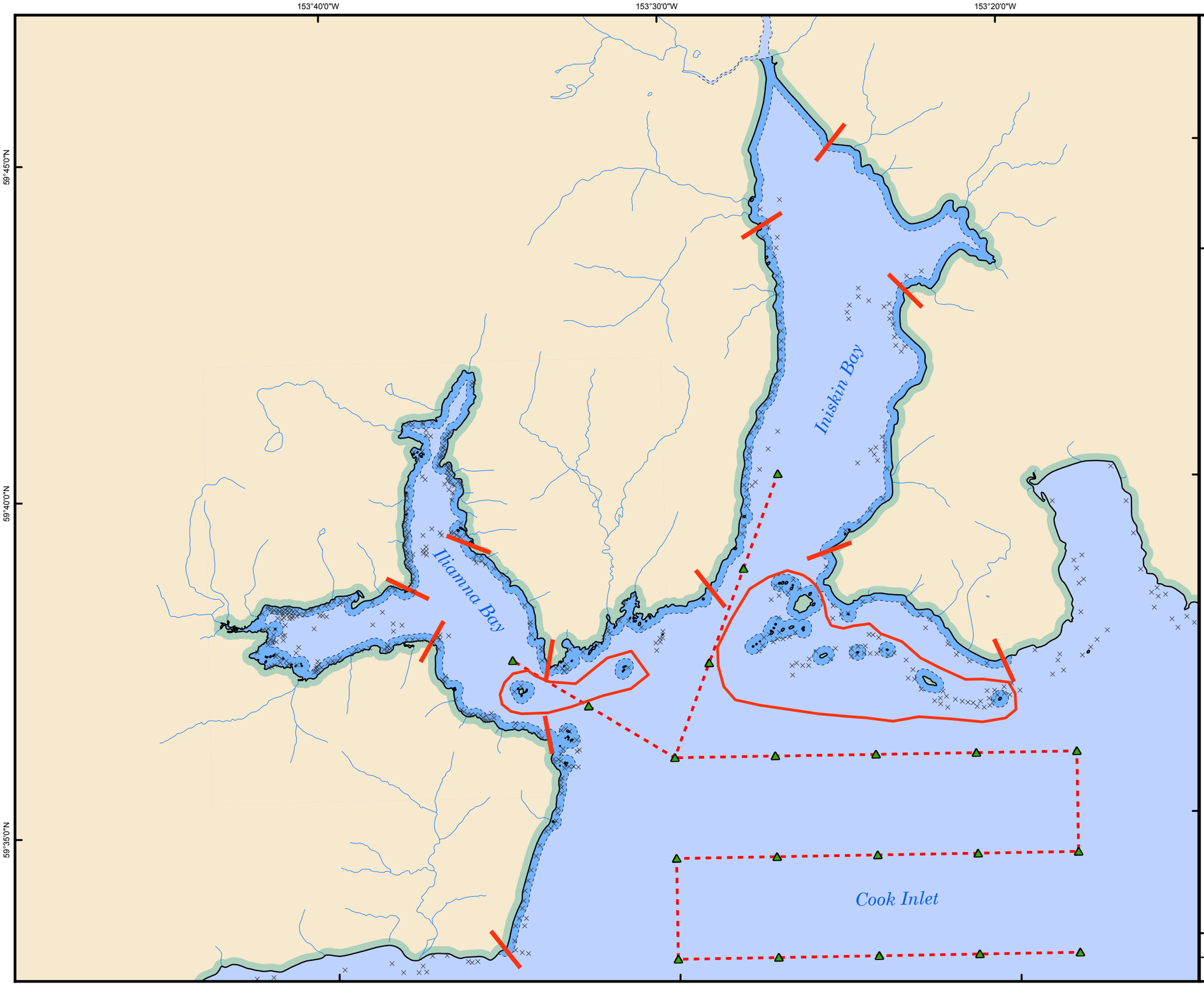
FIGURES



Northern Dynasty Mines Inc.

Pebble Project

Nearshore and offshore marine wildlife survey areas, Pebble port sites, summer and late fall-winter 2004.
Figure 12 - 1

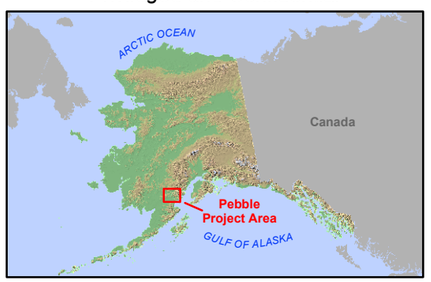
Nearshore ~650-ft (200-m) Zone

Nearshore Segment Breaks

Offshore Segment Lines

Offshore Segment Breaks

Privileged and Confidential



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Scale 1:105,000

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1983 North American Datum

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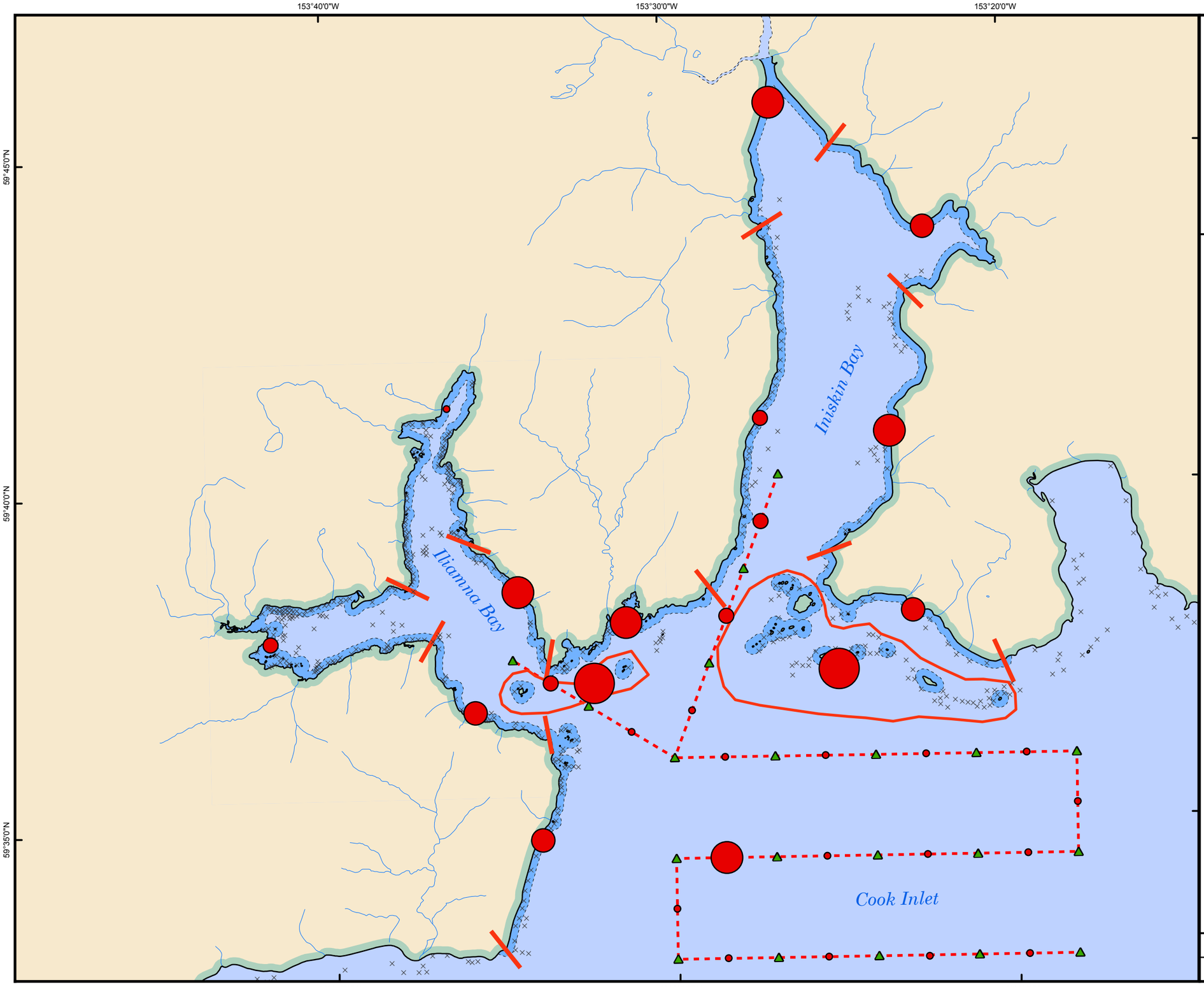
Version: 1	Author: ABR-DD

Northern Dynasty Mines Inc.

Pebble Project

Densities of birds (birds/mi^2) during nearshore and offshore surveys, Pebble port sites, summer 2004.
Figure 12 - 2

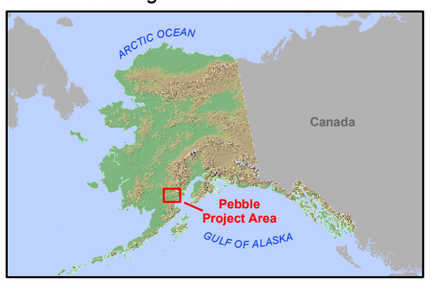


Bird Density (birds/mile^2)
Summer 2004

- 0.01 – 50.00
- 50.01 – 100.00
- 100.01 – 200.00
- 200.01 – 500.00
- > 500.00

- Nearshore Segment Breaks
- Offshore Segment Lines
- Offshore Segment Breaks

Privileged and Confidential



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Alaska State Plane Zone 5 (units feet)
1983 North American Datum

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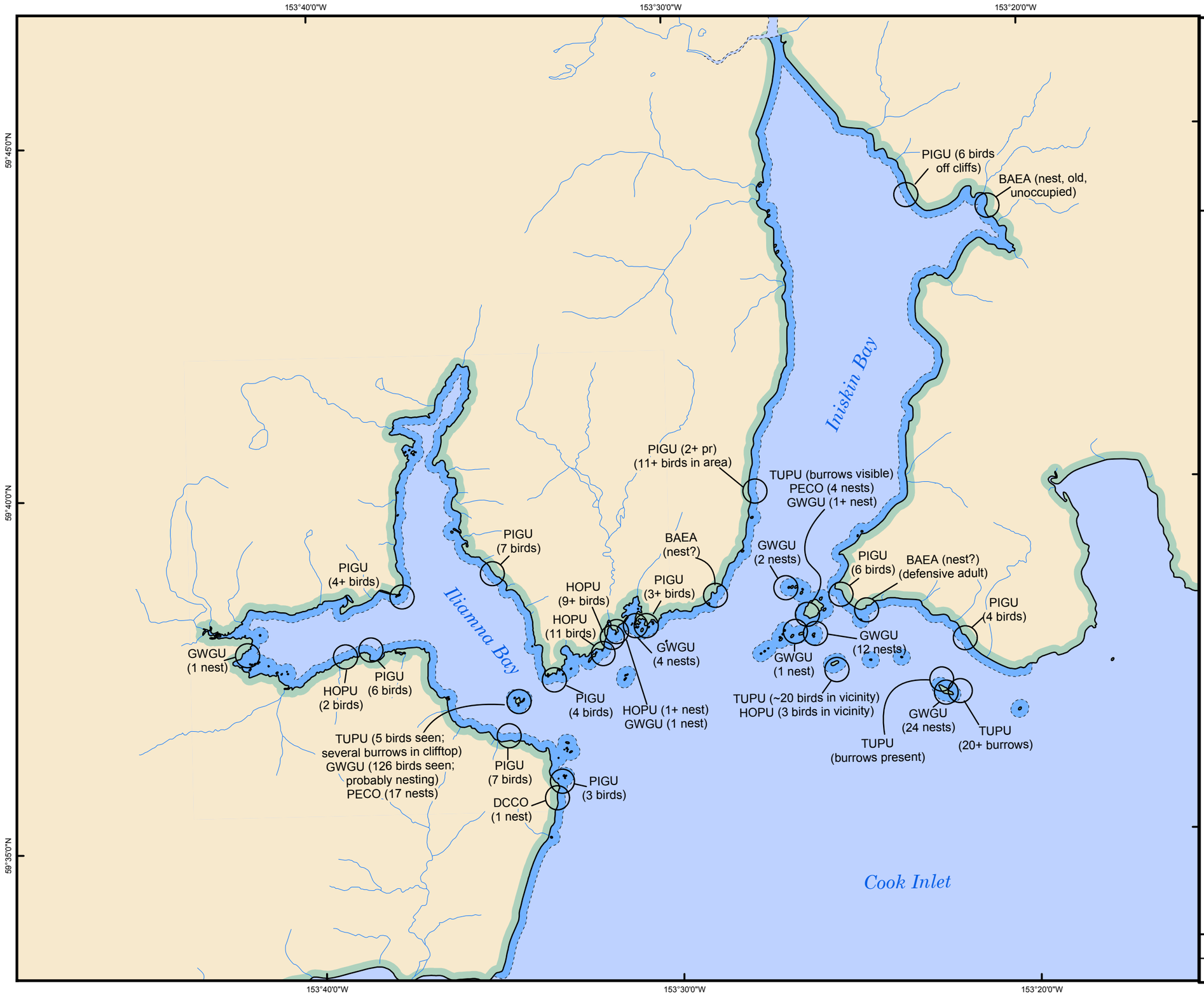
Northern Dynasty Mines Inc.

Pebble Project

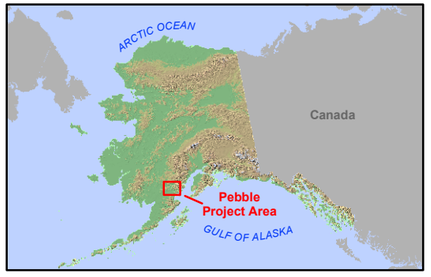
Numbers of breeding birds,
Pebble port sites, summer 2004.
Figure 12 - 3



Breeding Birds
Summer 2004

BAEA	Bald Eagle
DCCO	Double-crested Cormorant
GWGU	Glaucous-winged Gull
HOPU	Horned Puffin
PECO	Pelagic Cormorant
PIGU	Pigeon Guillemot
TUPU	Tufted Puffin

Privileged and Confidential



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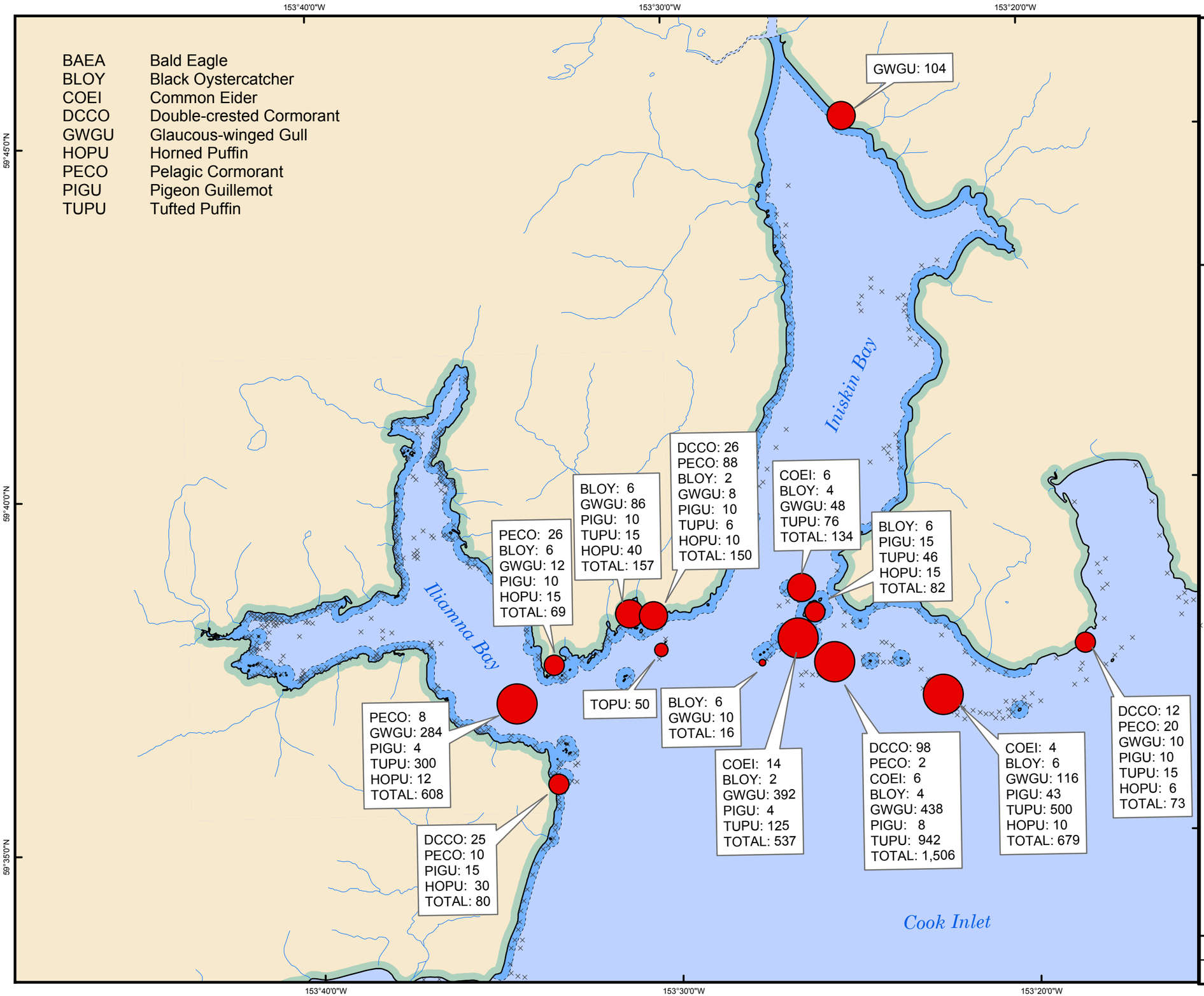

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Pebble Project

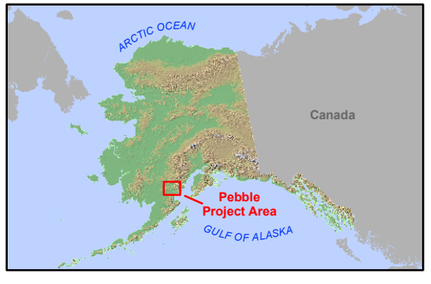
Numbers of breeding birds, as listed in the *Alaska Seabird Colony Catalog*, Pebble port study area.
Figure 12 - 4

Alaska Seabird Colony Catalog

(Number of Birds)

- 0 – 9
- 10 – 49
- 50 – 99
- 100 – 499
- > 500

Privileged and Confidential



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Kilometers: 0 1 2 3 4 5
Scale 1:100,000
N

Alaska State Plane Zone 5 (units feet)
1983 North American Datum

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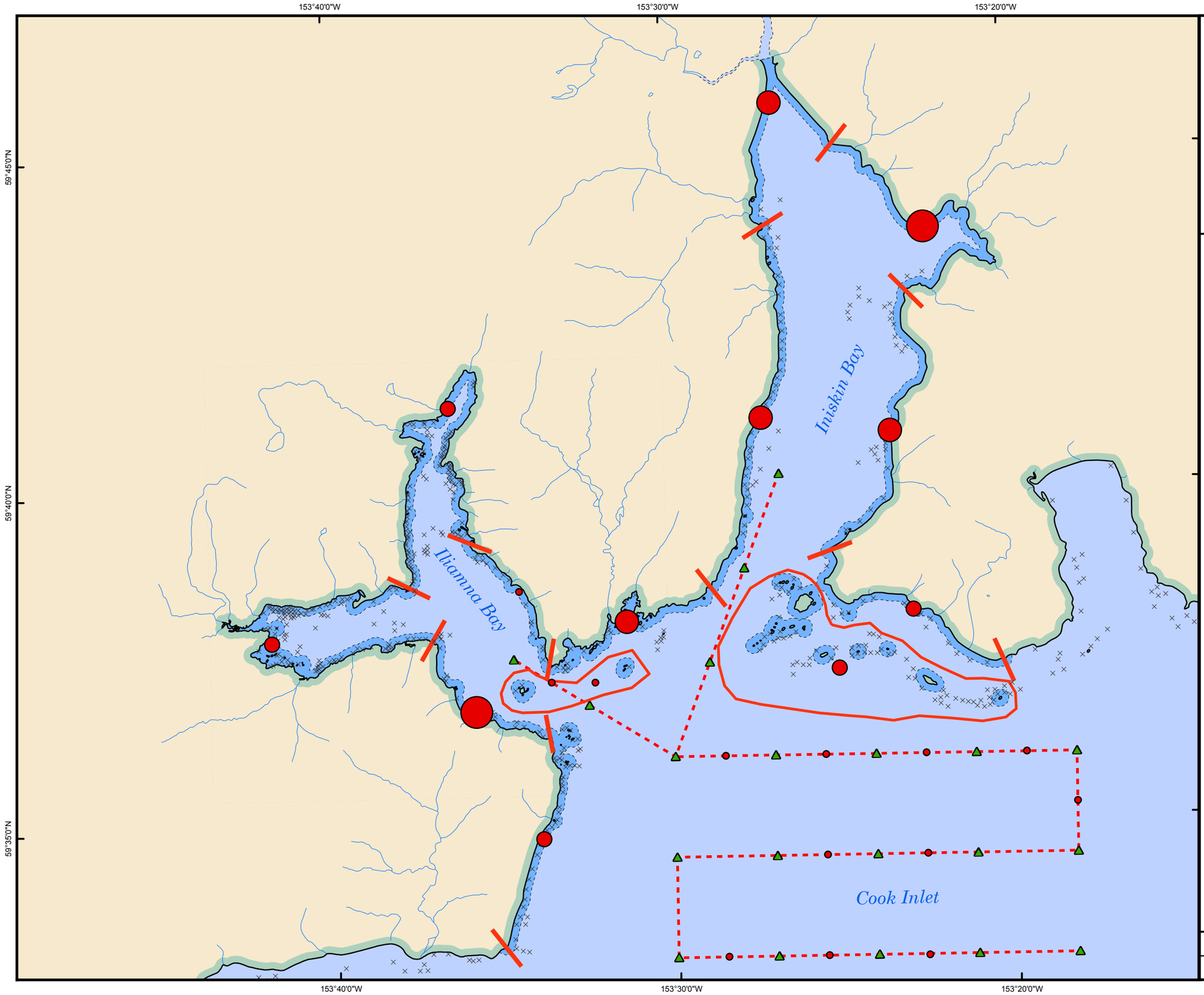
Version: 1	Author: ABR-DD

Northern Dynasty Mines Inc.

Pebble Project

Densities of birds (birds/mi^2) during nearshore and offshore surveys, Pebble port sites, late fall/winter 2004.
Figure 12 - 5

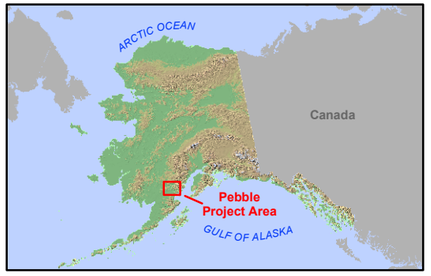


Bird Density (birds/mile^2)
Fall – Winter 2004

- 0.01 – 50.00
- 50.01 – 100.00
- 100.01 – 200.00
- 200.01 – 500.00
- > 500.00

- Nearshore Segment Breaks
- Offshore Segment Lines
- Offshore Segment Breaks

Privileged and Confidential



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Kilometers 0 1 2 3 4 5
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Alaska State Plane Zone 5 (units feet)
1983 North American Datum

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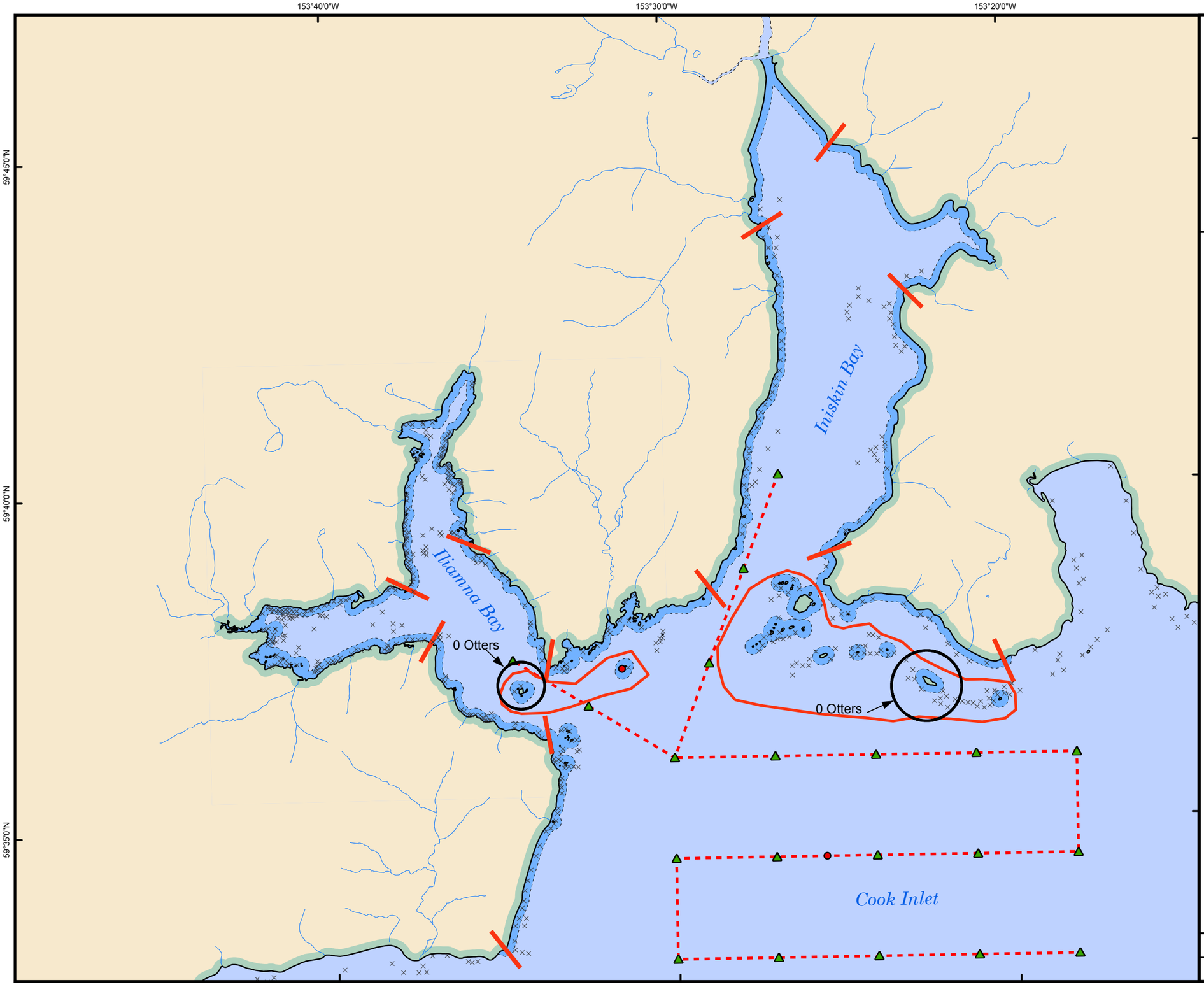

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Pebble Project

Numbers of sea otters on nearshore and offshore surveys, Pebble port sites, summer 2004.
FIgure 12 - 6

Sea Otters

Summer 2004

(Number of Individuals)

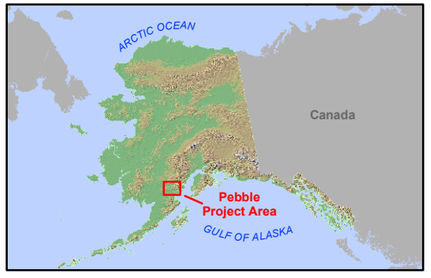
- 1
- 2 - 5
- 6 - 10
- 11 - 20
- 21 - 40

Nearshore Segment Breaks

Offshore Segment Lines

Offshore Segment Breaks

Privileged and Confidential



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Kilometers 0 1 2 3 4 5

Scale 1:105,000

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Alaska State Plane Zone 5 (units feet)
1983 North American Datum

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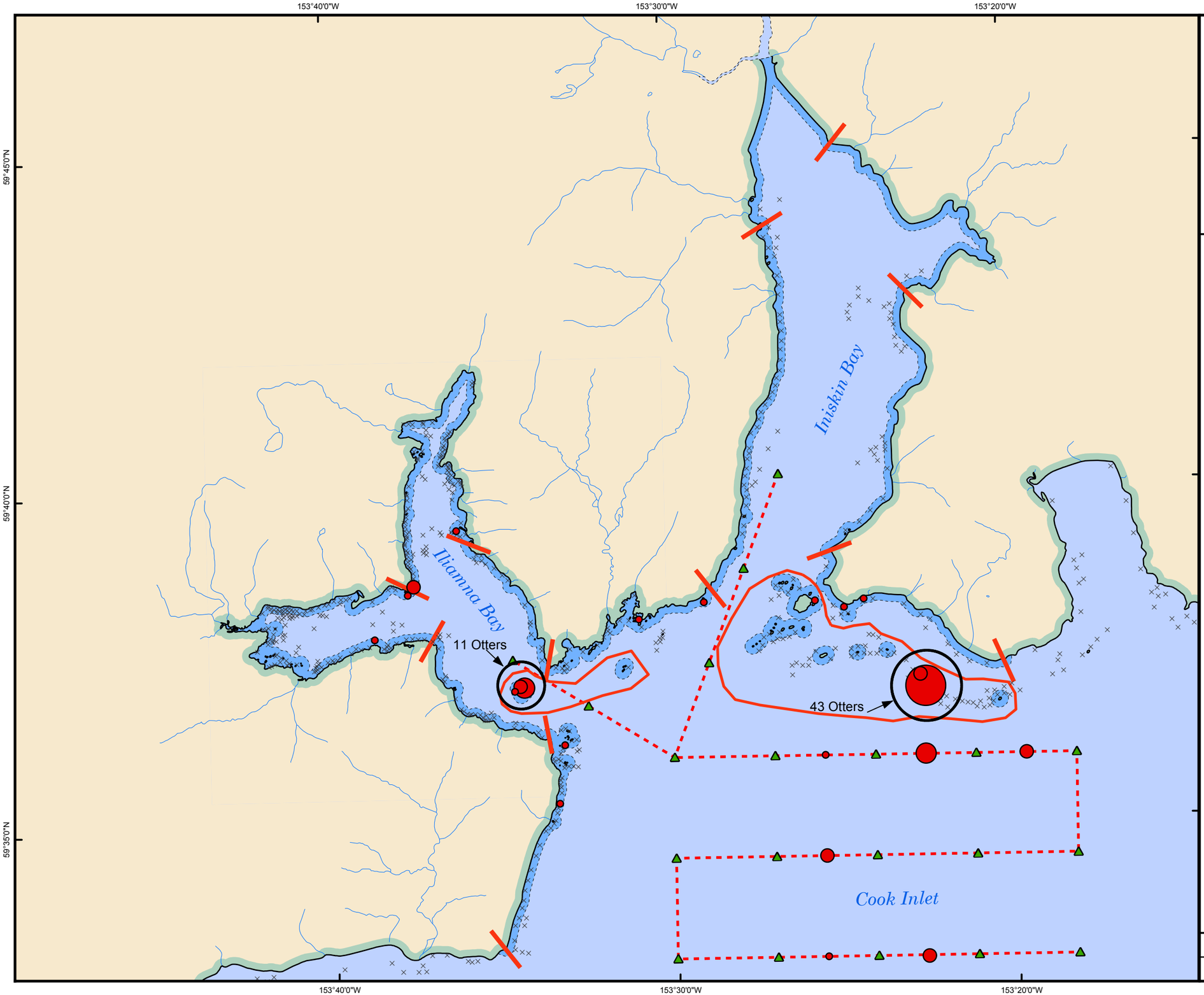

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Pebble Project

Numbers of sea otters on nearshore and offshore surveys, Pebble port sites, late fall/winter 2004.
Figure 12 - 7

Sea Otters

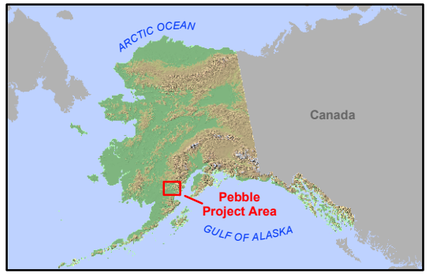
Fall – Winter 2004

(Number of Individuals)

- 1
- 2 - 5
- 6 - 10
- 11 - 20
- 21 - 40

- Nearshore Segment Breaks
- Offshore Segment Lines
- Offshore Segment Breaks

Privileged and Confidential



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Kilometers: 0 1 2 3 4 5

Scale 1:105,000

N

Alaska State Plane Zone 5 (units feet)
1983 North American Datum

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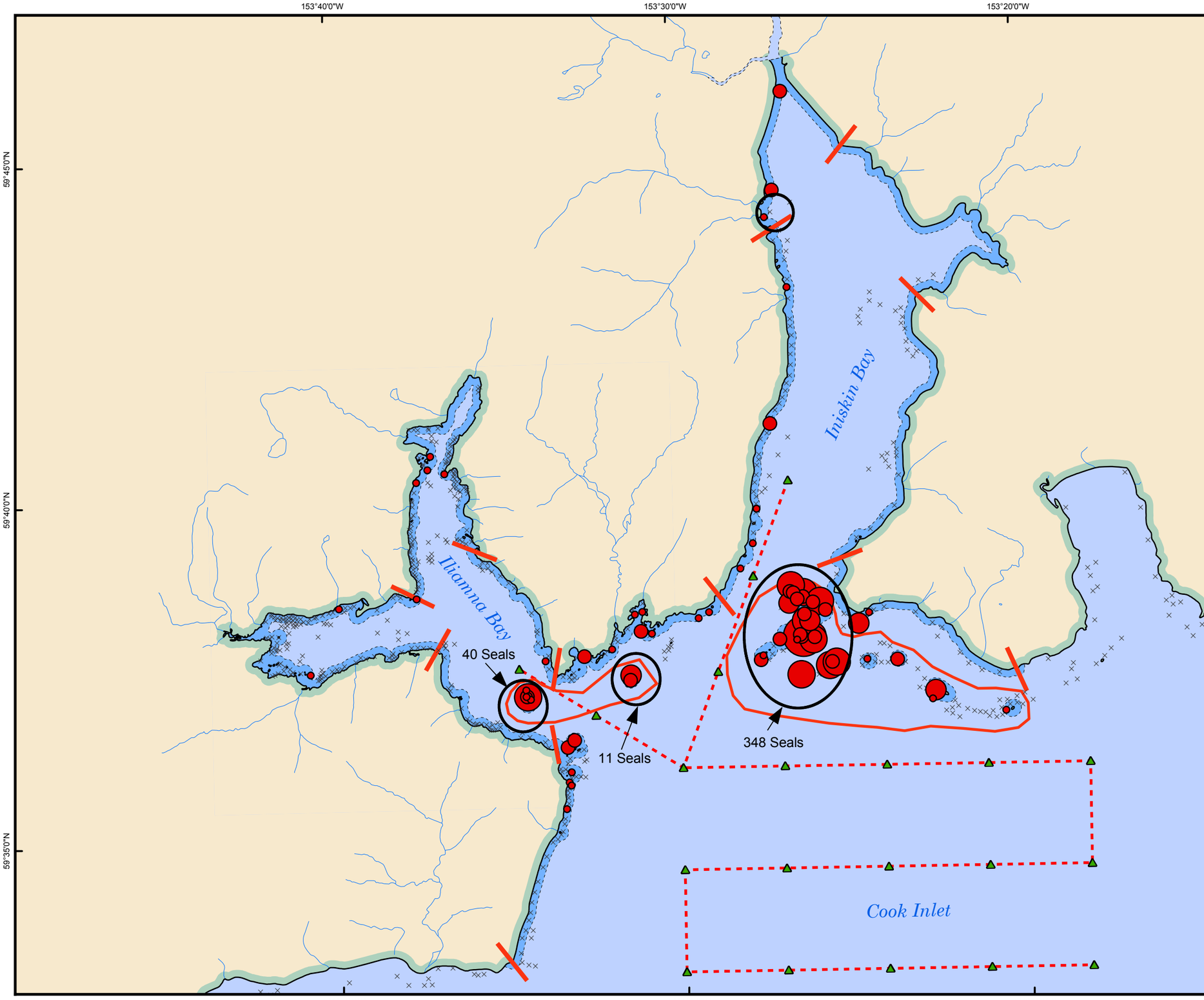
Version: 1	Author: ABR-DD

Northern Dynasty Mines Inc.

Pebble Project

Numbers of harbor seals on nearshore and offshore surveys, Pebble port sites, summer 2004.
Figure 12 - 8



Harbor Seals

Summer 2004

(Number of Individuals)

- 1
- 2 - 5
- 6 - 10
- 11 - 50
- 51 - 150

- Nearshore Segment Breaks
- Offshore Segment Lines
- Offshore Segment Breaks

Privileged and Confidential

Miles: 0 1 2 3

Kilometers: 0 1 2 3 4 5

Scale 1:105,000

N

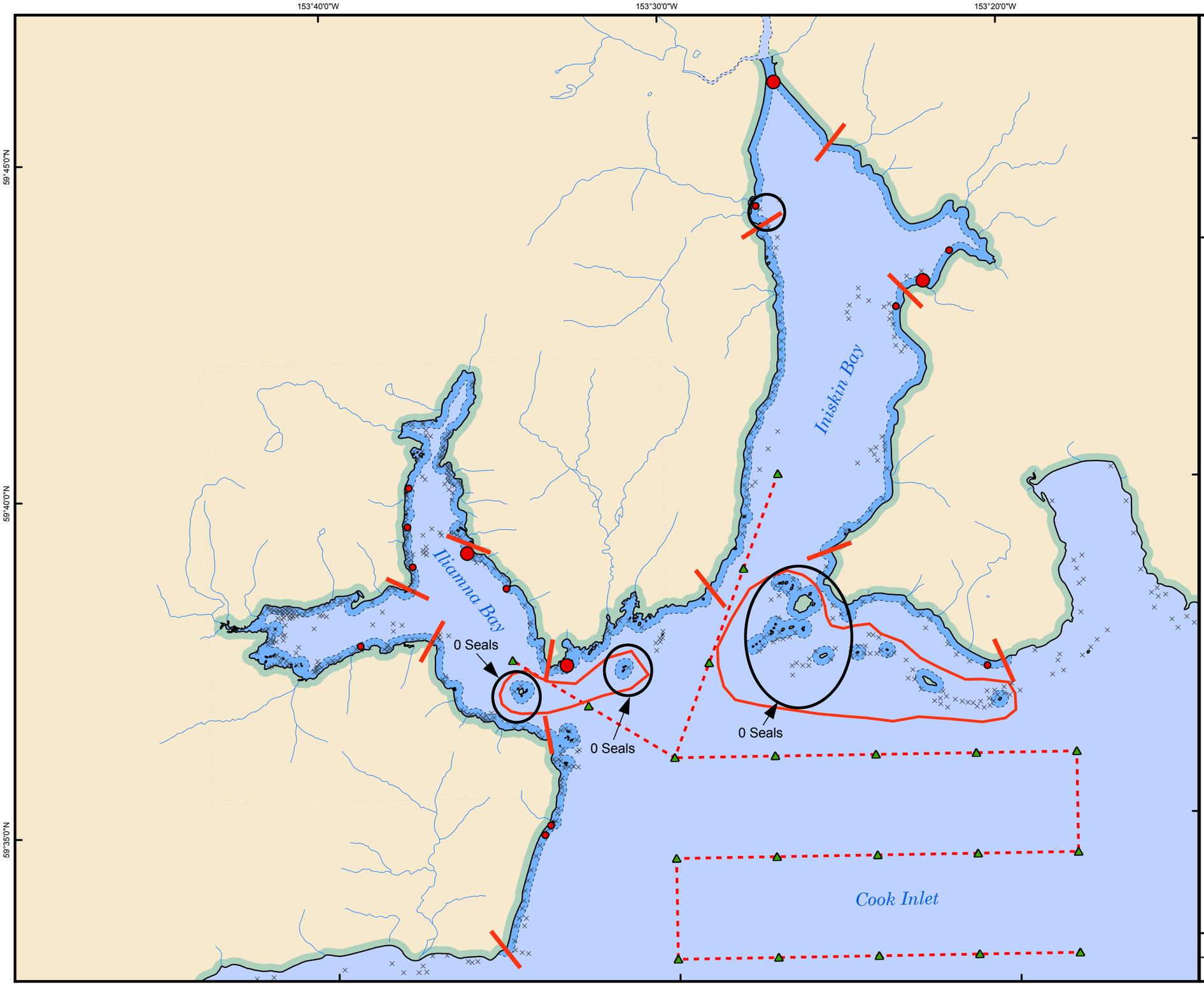
Alaska State Plane Zone 5 (units feet)
1983 North American Datum

File: Harbor_Seals_Summer2004_05-170-8.mxd	Date: Jan. 12, 2005
Version: 1	Author: ABR-DD

Northern Dynasty Mines Inc.

Pebble Project

Numbers of harbor seals on nearshore and offshore surveys, Pebble port sites, late fall/winter 2004.
Figure 12 - 9



Harbor Seals

Fall – Winter 2004

(Number of Individuals)

- 1
- 2 - 5
- 6 - 10
- 11 - 50
- 51 - 150

- Nearshore Segment Breaks
- Offshore Segment Lines
- Offshore Segment Breaks

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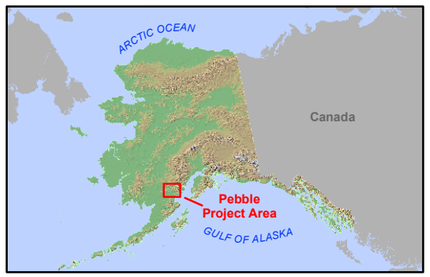

Miles 0 1 2 3

Kilometers 0 1 2 3 4 5

Scale 1:105,000

N

Alaska State Plane Zone 5 (units feet)
1983 North American Datum

File: Harbor_Seals_Winter2004_05-170-8.mxd	Date: Jan. 12, 2005
Version: 1	Author: ABR-DD

Northern Dynasty Mines Inc.

Pebble Project

Iliamna and Iniskin Bays

Figure 12-10.

Legend

Port Site*

*Port sites as of June 2004 (PN&D, 2004)

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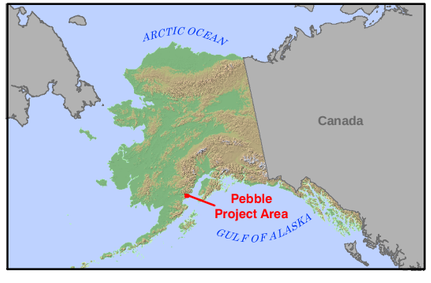

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Kilometers: 0, 0.8, 1.6, 2.4, 3.2

Scale 1:70,000

Alaska State Plane Zone 5 (units US feet)
1983 North American Datum

File: Port_01_V01.mxd	Date: Feb. 10, 2005
Version: 1	Author: BEESC-ME

Northern Dynasty Mines Inc.

Pebble Project

2004 Intertidal Sampling Sites

Figure 12-11

Legend

- Infauna Sample
- Rocky Intertidal Sample
- Sediment Chemistry
- Port Site*

*Port sites as of June 2004 (PN&D, 2004)

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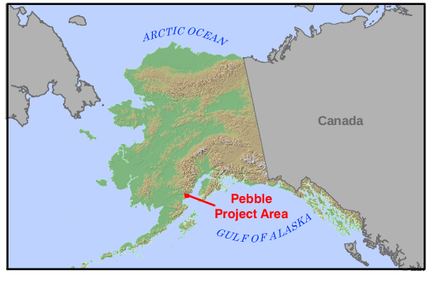


N

0 0.6 1.2 1.8 2.4 Miles

0 0.8 1.6 2.4 3.2 Kilometers

Scale 1:70,000

Alaska State Plane Zone 5 (units US feet)
1983 North American Datum

File: Port_02_V01.mxd	Date: Feb. 10, 2005
Version: 1	Author: BEESC-ME

Northern Dynasty Mines Inc.

Pebble Project

2004 Beach Seine Sites

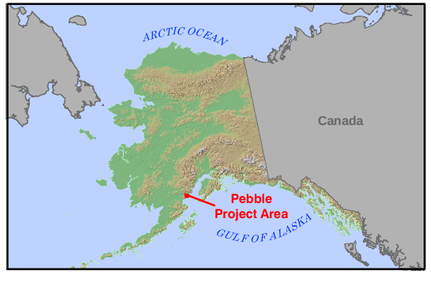
Figure 12-12

Legend

- Beach Seine
- Port Site*

*Port sites as of June 2004 (PN&D, 2004)

Privileged and Confidential



N

Miles: 0 0.6 1.2 1.8 2.4

Kilometers: 0 0.8 1.6 2.4 3.2

Scale 1:70,000

Alaska State Plane Zone 5 (units US feet)
1983 North American Datum

File: Port_03_V01.mxd	Date: Feb. 10, 2005
Version: 1	Author: BEESC-ME

Northern Dynasty Mines Inc.

Pebble Project

2004 Diver Transect Locations

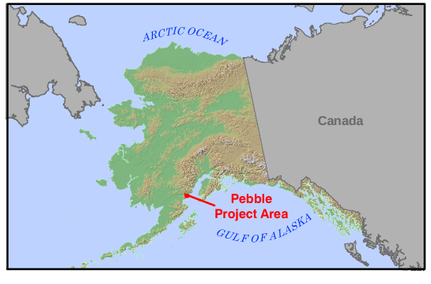
Figure 12-13

Legend

- Diver Transect
- Port Site*

*Port sites as of June 2004 (PN&D, 2004)

Privileged and Confidential



N

0 0.6 1.2 1.8 2.4 Miles

0 0.8 1.6 2.4 3.2 Kilometers

Scale 1:70,000

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1983 North American Datum

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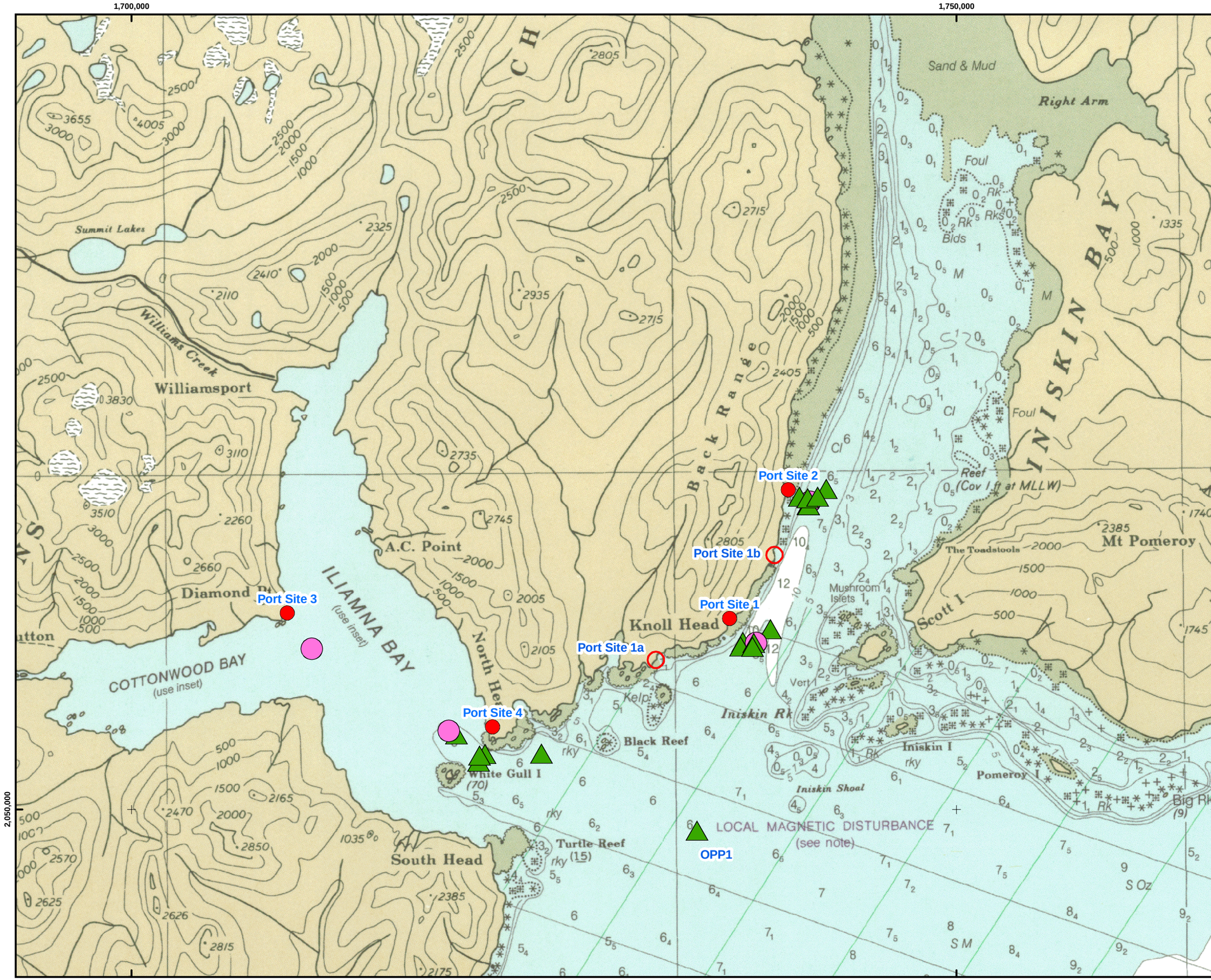


Northern Dynasty Mines Inc.

Pebble Project

2004 Subtidal and Water Sample Locations

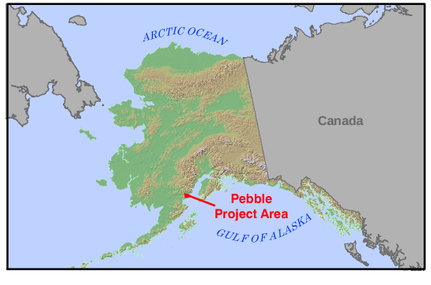
Figure 12-14

Legend

- Offshore Sediment
- Offshore Water
- Port Site*

*Port sites as of June 2004 (PN&D, 2004)

Privileged and Confidential



N

Miles: 0 0.6 1.2 1.8 2.4

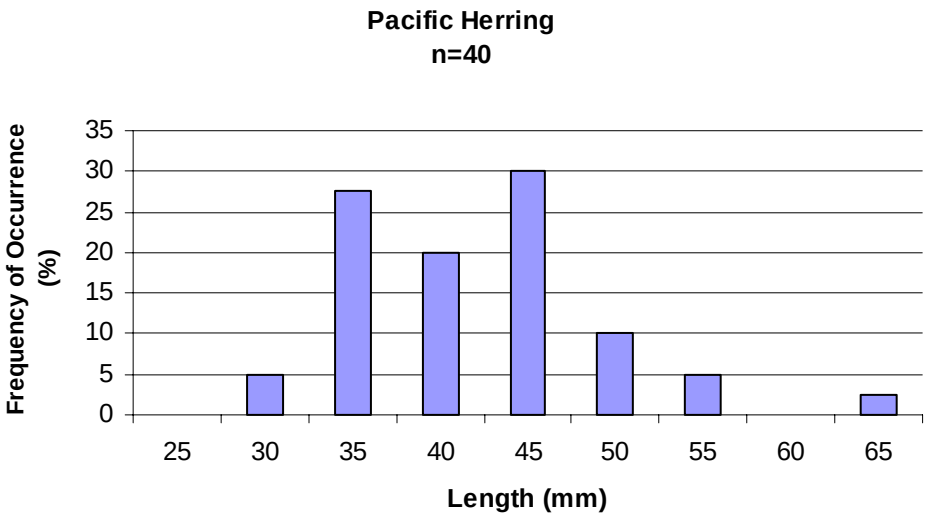
Kilometers: 0 0.8 1.6 2.4 3.2

Scale 1:70,000

Alaska State Plane Zone 5 (units US feet)
1983 North American Datum

File: Port_05_V01.mxd	Date: Feb. 10, 2005
Version: 1	Author: BEESC-ME

FIGURE 12-15
Length-frequency of Forage Fish Collected by Beach Seine (3 sets) at Port Site 1b



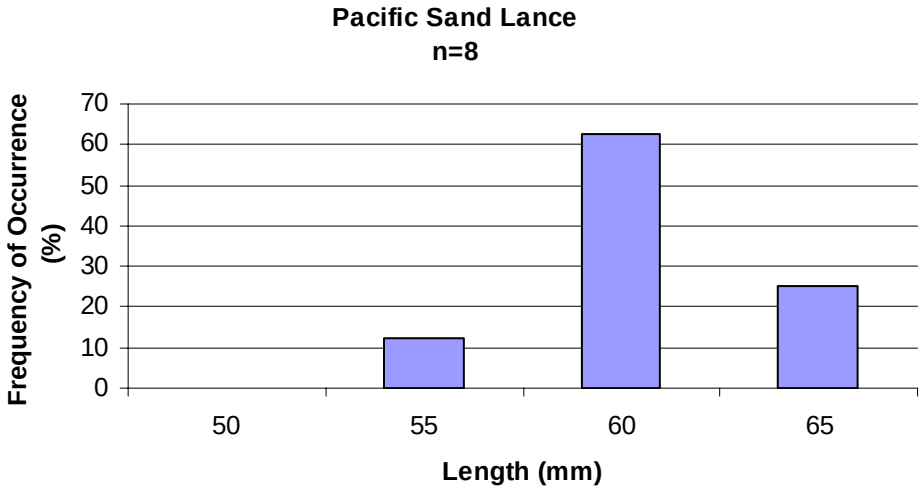


FIGURE 12-16
Length-frequency of Pacific Herring Collected by Beach Seine at Port Site 4

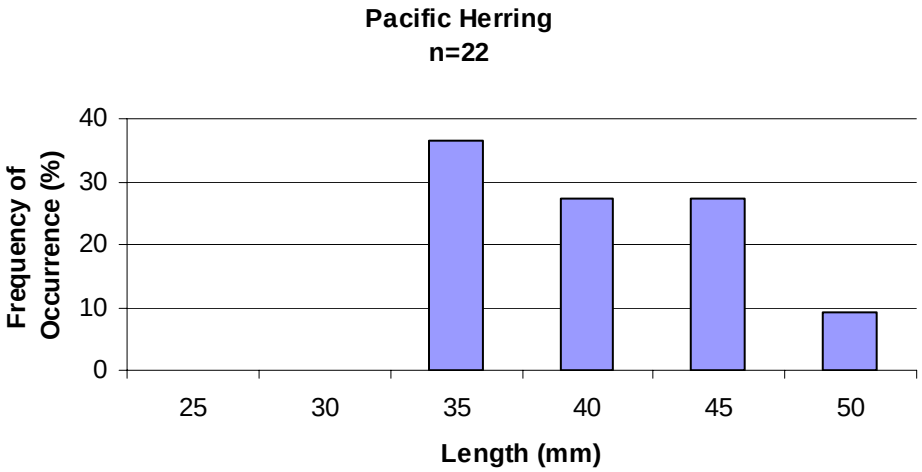


FIGURE 12-17
Length-frequency of Pacific Herring Collected by Beach Seine at Port Site Existing (Williamsport)

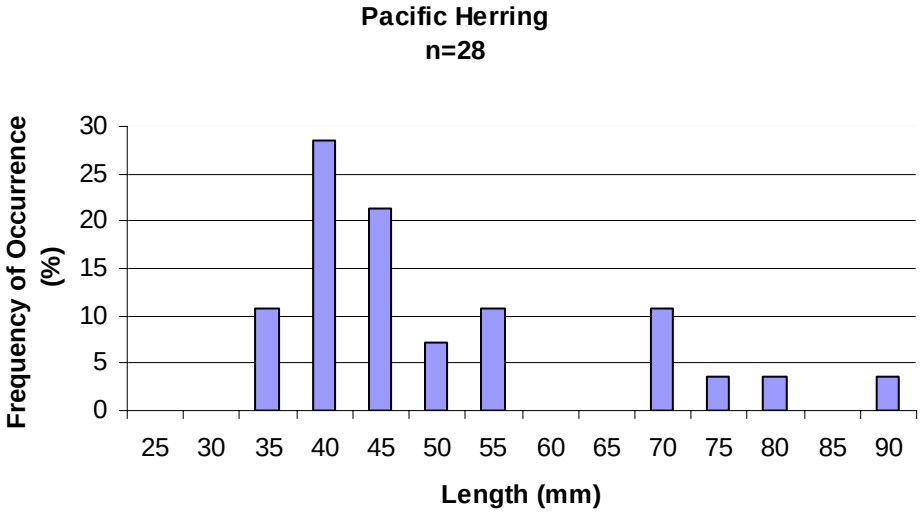
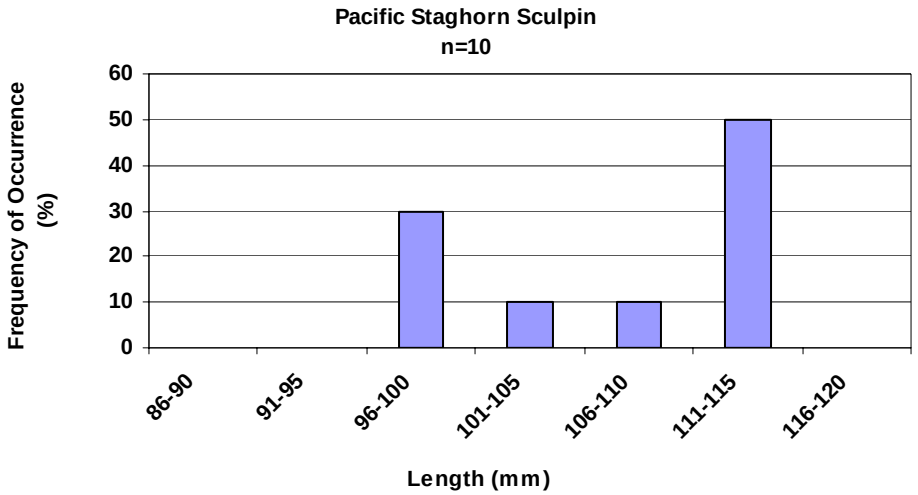
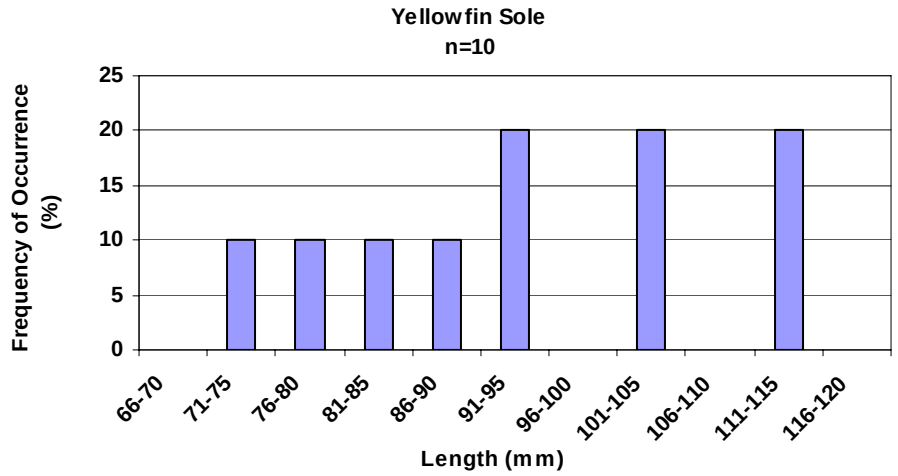
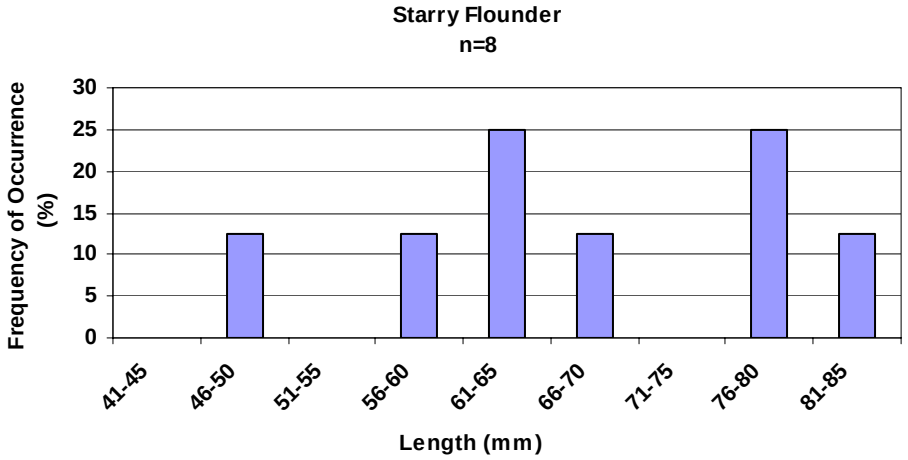


FIGURE 12-18
Length-frequency of Fish Collected by Trawl off Port Site 2



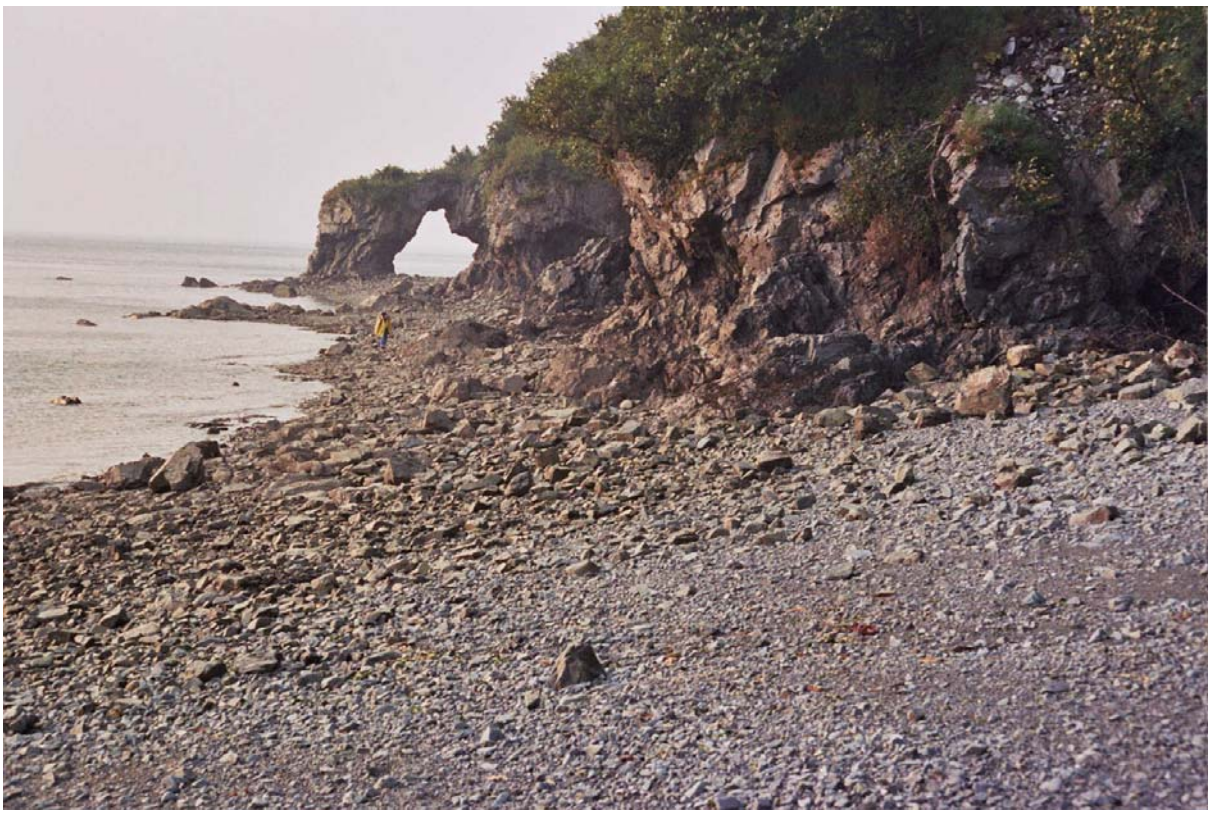




PHOTOGRAPHS

PHOTGRAPH 12-1. Knoll Head area looking north toward “Y” Valley, August 29, 2004.

PHOTGRAPH 12-2. Knoll Head—Port Site 1, arches.



PHOTGRAPH 12-3. Port Site 2 showing cliffs and east slope of Knoll Head.

PHOTGRAPH 12-4. Port Site 2, low mud transect.

PHOTGRAPH 12-5. Rock reef at Port Site 3, Diamond Point.

PHOTGRAPH 12-6. Port Site 4, gravel upper beach and rock outcrop.

PHOTGRAPH 12-7. Blackie Beach looking south.

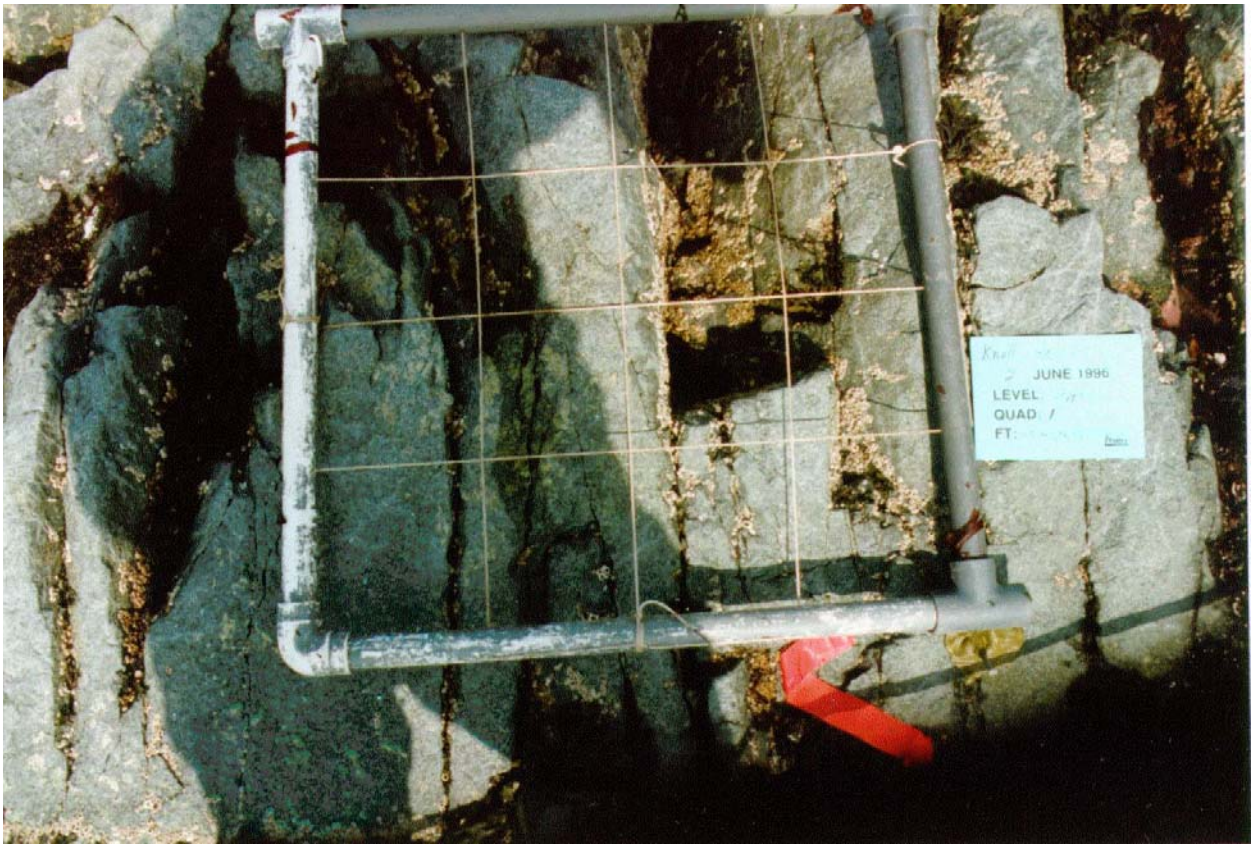
PHOTGRAPH 12-8. Scott Island sample area looking south (June 1996).

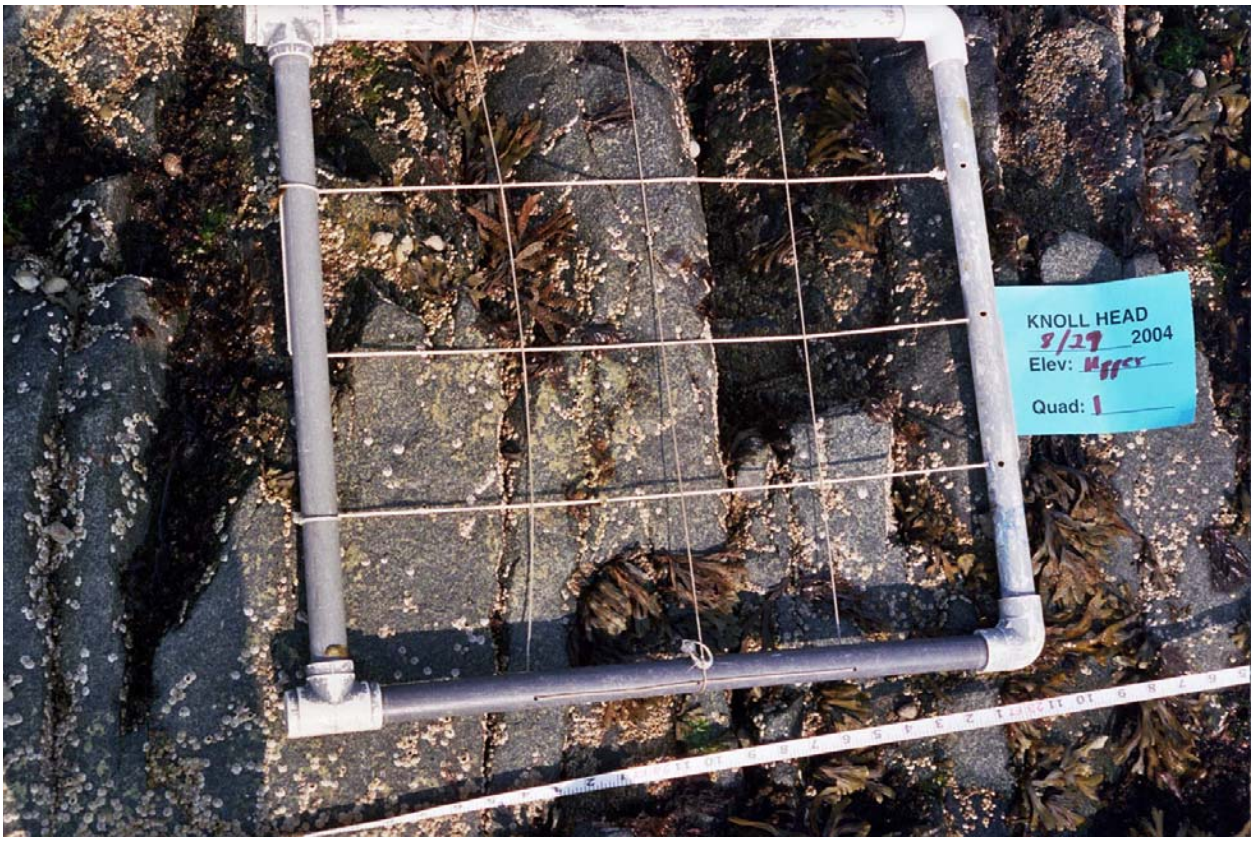
PHOTGRAPH 12-9. Williamsport area, inner Iliamna Bay.

PHOTGRAPH 12-10. Knoll HEAD – Port Site 1, low rock reef.

PHOTGRAPH 12-11. Knoll Head—Port Site 1a, panorama toward Black Reef.

PHOTGRAPH 12-12. Knoll Head—Port Site 1a, upper transect.



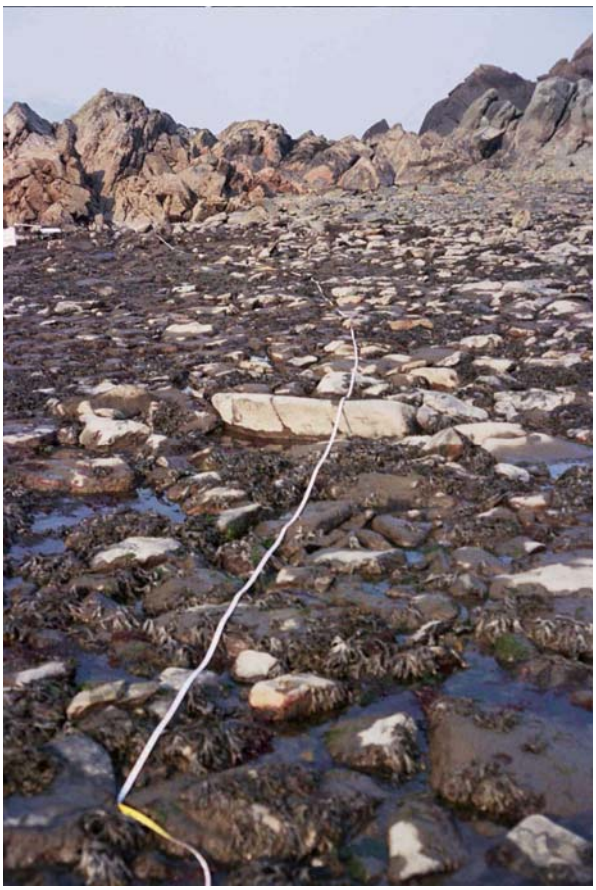


PHOTGRAPH 12-13. Knoll Head upper transect, quadrat 1; June 1996 (top) and August 2004 (bottom).

PHOTGRAPH 12-14. Knoll Head mid transect; May/June 1978 (top), June 1996 (mid), and August 2004 (bottom).

PHOTGRAPH 12-15. Port Site 2 mid transect.

PHOTGRAPH 12-16. Diamond Point—Port Site 3.



PHOTGRAPH 12-17. Port Site 4 mid transect.

PHOTGRAPH 12-18. Scott Island upper transect.

PHOTGRAPH 12-19. Scott Island upper transect, quadrat 2; June 1996 (top) and September 2004 (bottom).

PHOTGRAPH 12-20. Scott Island mid transect; June 1996 (top) and September 2004 (bottom).

PHOTGRAPH 12-21. Scott Island low transect; June 1996 (top) and September 2004 (bottom).

PHOTGRAPH 12-22. Port Site 3, low sand and mud looking towards Diamond Point.

PHOTGRAPH 12-23. Port Site 4 looking south toward soft sediment-sampling areas.

PHOTGRAPH 12-24. Eelgrass patch in Williamsport area of inner Iliamna Bay.

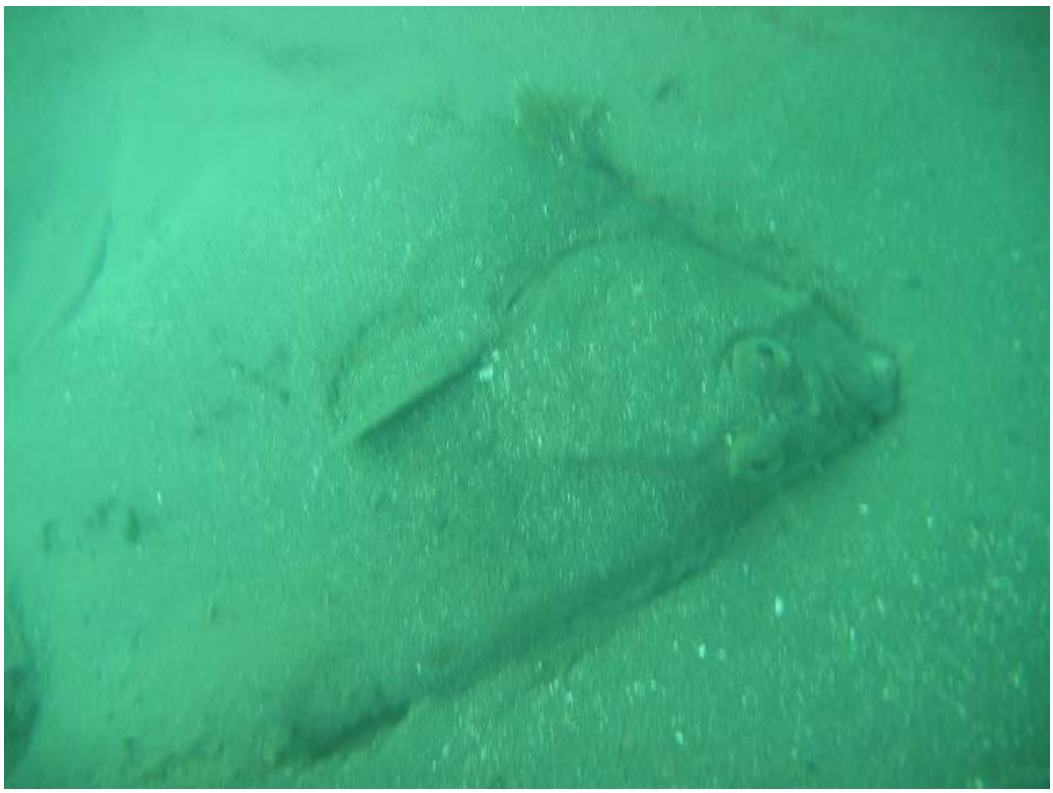
PHOTGRAPH 12-25. Typical beach seine catch of juvenile herring and small ctenophores.

PHOTOGRAPH 12-26. Dense cluster of sabellid polychaete (*Schizobranchia insignis?*), typical of soft sand/silt substrate at Port Site 1, August 29, 2004. This tubiculous suspension-feeding polychaete dominated bottom with discontinuous clusters, especially at 15 ft below MLLW (photograph of an approx. 1-ft by 1-ft area).

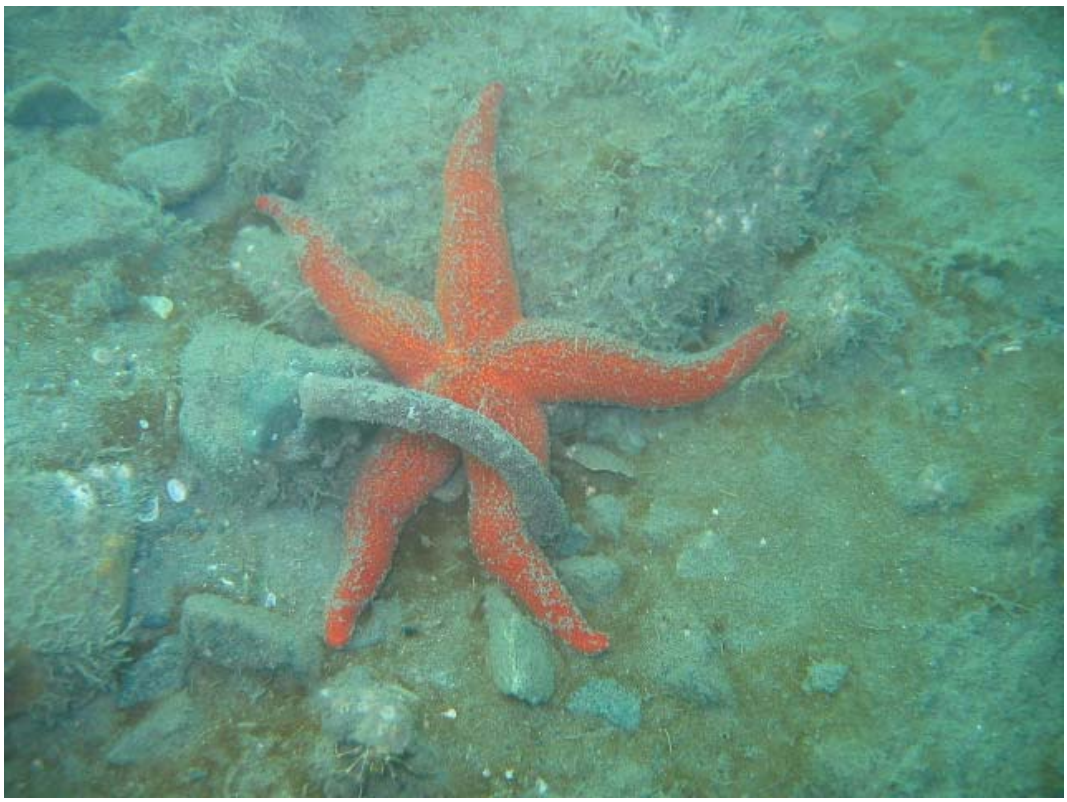
PHOTGRAPH 12-27. Hermit crabs (e.g., *Pagurus*) on boulder covered with pink encrusting coralline algae (Rhodophyta) and an orange sponge (*Suberites*?), typical of subtidal cobble/boulder habitat at Port Site 1, August 29, 2004. (photograph of an approx. 1-ft by 1-ft area).

PHOTGRAPH 12-28. Hermit crab (*Elassochirus tenuimanus*) amid patch of tubiculous polychaete *Schizobranchia insignis?*, on sand/silt substrate at Port Site 1, August 29, 2004.

PHOTGRAPH 12-29. Sea anemone (*Urticina crassicornis*) and typical subtidal cobble/boulder habitat at Port Site 4 (North Head), August 30, 2004. (photograph of an approx. 1-ft by 1-ft area).



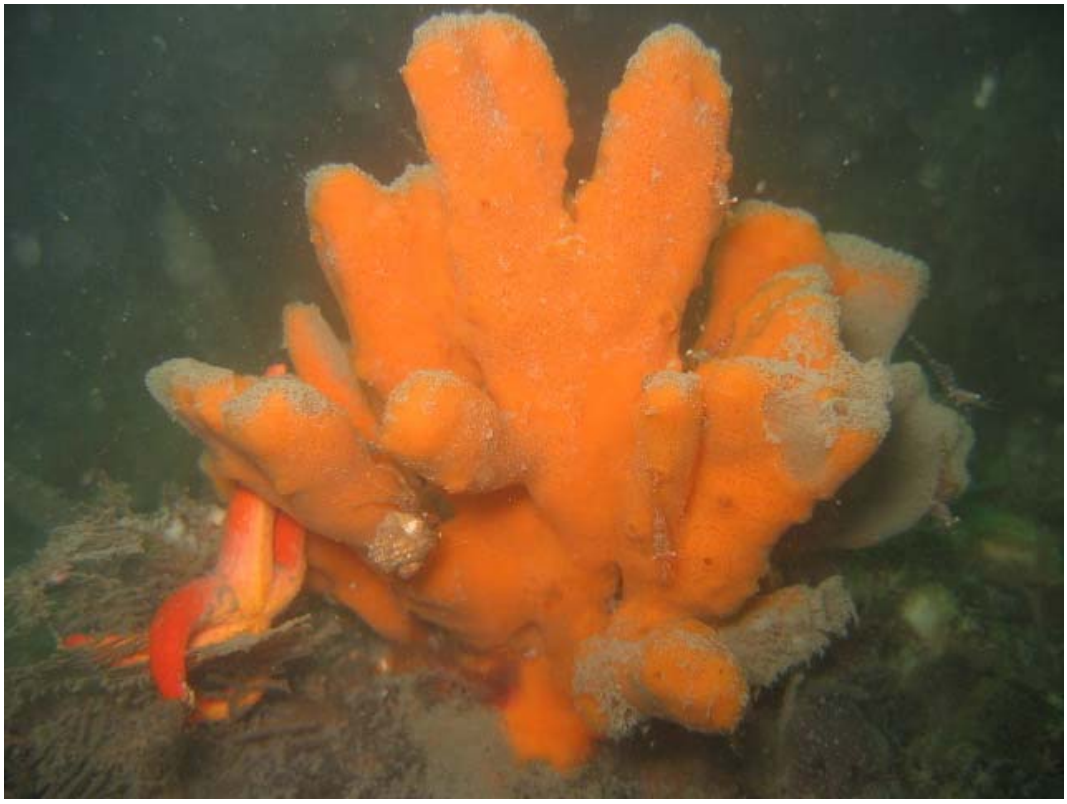
PHOTGRAPH 12-30. Starry flounder (*Platichthys stellatus*) partially buried in sand/silt at Port Site 4 (North Head), August 30, 2004. (photograph of an approx. 1-ft by 1-ft area).



PHOTGRAPH 12-31. Blood sea star (*Henricia leviuscula*) on coarse bottom at Port Site 4 (North Head), August 30, 2004. Laying across sea star is a single tubiculous anemone (*Pachycerianthus fimbriatus*). (photograph of an approx. 1-ft by 1-ft area).

PHOTGRAPH 12-32. Probable whitespotted greenling (*Hexagrammos stelleri*) from south side of White Gull Island, August 30, 2004. (photograph of an approx. 1-ft by 1-ft area).

PHOTGRAPH 12-33. Sea anemone (*Metridium giganteum*) from south side of White Gull Island, August 30, 2004. (photograph of an approxi. 1-ft by 1-ft surface area).



PHOTGRAPH 12-34. Sea sponge (*Suberites*?) from south side of White Gull Island, August 30, 2004.

APPENDICES

APPENDIX 12-A
Sources Consulted for Literature Synthesis

Sources Consulted for Literature Synthesis

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APPENDIX 12-B
Intertidal Habitat Assemblages

INTERTIDAL HABITAT ASSEMBLAGES

12B.1 Introduction

Sampling was conducted at the intertidal stations in the Iniskin/Iliamna Estuary in August 2004. This appendix summarizes the dominant species identified at each site, along with less numerically abundant but ecologically important "keystone species."

Key elevations sampled quantitatively in rocky intertidal habitats were selected in the middle of the vertical range of a portion of shoreline with representative assemblages seen to be widespread within that shoreline reach. Two rocky intertidal sites previously sampled in 1978 and 1996 (Port Site 1 and Scott Island) were resampled at the upper and middle intertidal elevations, and one also was resampled at the lower elevation. With the help of photographs and previously placed markers, these stations were resampled as close as possible to the locations previously sampled. New rocky intertidal sites were established in 2004 near all proposed port sites for the Pebble Project.

At each elevation sampled, a 30-meter transect line was laid out along the tidal-elevation contour line. Along each transect, five to ten 0.25-square-meter quadrats were randomly located or, in the case of previously sampled sites, located again. In each quadrat, percent cover of all algal species and all sessile animals was first estimated. Then, counts were made of all mobile species larger than about 4 millimeters in size. These data provide a quantitative baseline for comparisons with the data available from previous work in IIE and for assessment of potential project impacts. The following sections summarize observations made during this sampling. Detailed species lists compiled for each habitat type and elevation are included.

12B.2 Port Site 1 (Knoll Head)

This site lies on a low bedrock reef projecting seaward in front of the vertical cliffs that lie at the base of Knoll Head (Figure 12-11). Only the lower elevation was sampled at approximately -1 foot MLLW (Photo 12-10). The rock substrate was dominated by brown algae and red algae; mean algal cover (all species) was nearly 90 percent (Table 12B-1). The kelps *Laminaria* sp., *L. groenlandica*, and *Alaria marginata* formed an overstory above the many species of smaller red algae, dominated by *Palmaria* spp. Encrusting coralline algae covered 20 percent of the rock surface. Animals were generally sparse with only the very small snail *Lacuna* sp. and newly set barnacles, probably *Balanus rostratus*, fairly abundant. Next most abundant animals were the scavenging hermit crabs, *Pagurus hirsutiusculus* and *P. beringanus*.

TABLE 12B-1
Macrobiota at Port Site 1 (Knoll Head) Lower Intertidal Transect—August 2004

Lower Elevation (n=6)					
Species	**Mean**	**S.D.**	**Species**	**Mean**	**S.D.**
Plants (% cover)			**Animals (#/0.25 m^2)**		
Acrosiphonia arcta	3.75	8.00	*Cancer oregonensis*	0.17	0.41
Alaria marginata	6.67	14.02	Cucumber, creamy	0.17	0.41
Alaria taeniata	0.50	1.22	Gray-orange anemone	0.17	0.41
Clathromorphum reclinatum	0.08	0.20	*Henricia leviuscula*	0.17	0.41
Constantinea subulifera	1.17	1.47	*Lacuna* sp.	present not counted	
Corallina frondescens	0.92	0.58	*Leptasterias* sp.	0.17	0.41
Cryptosiphonia woodii	0.33	0.82	*Lottia pelta*	0.17	0.41
Encrusting coralline algae	20.08	20.88	*Margarites pupillus* (spiral)	0.33	0.52
Fucus gardneri	1.17	2.40	Orange sponge	0.92	1.28
Halosaccion glandiforme	0.33	0.41	*Pagurus hirsutiusculus*	2.17	1.33
Laminaria groenlandica	8.83	11.75	*Pagurus beringanus*	2.00	1.67
Laminara sp.	15.83	28.36	*Pugetia gracilis (?)*	0.50	0.84
Mastocarpus papillatus	1.67	2.07	*Serpula vermicularis serpulidue*	0.08	0.20
Mazzaella parvula (?)	0.17	0.26	Sertulariidae hydroid	0.33	0.52
Mazzaella phyllocarpa	1.33	3.27	*Tectura scutum (?)*	0.17	0.41
Neohypophyllum middendorffii	0.17	0.41	*Tonicella lineata*	0.50	0.84
Palmaria callophylloides	3.00	4.56	*Urticina crassicornis*	0.17	0.41
Palmaria hecatensis	18.50	16.43			
Palmaria mollis	0.92	2.01	**Animals (% cover)**		
Petrocelis spp.	0.08	0.20	*Balanus rostratus,* juv.	30.08	25.77
Pilayella littoralis	0.08	0.20	Encrusting bryozoan	0.50	0.55
Porphyra aestivalis	1.67	2.66			
Porphyra variegata (?)	0.08	0.20	**Dead Animals (%)**		
Ralfsia fungiformis	0.50	0.84	*Balanus rostratus*	1.17	2.04
Ralfsia spp.	0.67	1.63			
Ulva sp.	0.42	0.20			
Total algal cover	**88.92**	**22.23**			

12B.3 Port Site 1a (Knoll Head West)

The Knoll Head West site was sampled several times in the 1970s by Lees et al. (1980) and in June 1996 by Pentec (1996). The site lies among rocky benches and headlands approximately midway between Knoll Head and the entrance to the lagoon between Knoll Head and North Head (Figure 12-11, Photos 12-1 and 12-11).

The upper elevation at Knoll Head West is located on top of a low, exposed ridge composed of 100 percent bedrock (Photo 12-12), at an elevation of approximately +4 to +6 feet MLLW. With the aid of photographs, the transect to be sampled was laid out precisely along the line sampled in 1996; several individual quadrat markers from that survey were located again (e.g., Photo 12-13). Pockets in the rock form small tide pools that occur in some of the quadrats sampled in both 1996 and 2004. A comparison of cover by major algal taxa, as measured in mid September 1978, June 1996, and late August 2004, is provided in Figure 12B-1. Total algal cover in late August 2004 was 38.7 percent (Table 12B-2), compared with 33 percent in 1996. Rockweed (*Fucus gardneri*) was nearly twice as abundant in 1978 as in the later two sample periods, but little change in dominance was seen between 1996 and 2004. The dominant species in all years was rockweed (15 percent in 2004, 13.5 percent in 1996), followed by the red alga *Neorhodomela oregona* (13.9 percent in 2004, 10.3 percent in 1996).

The percent of substrate covered with sessile animals (mostly barnacles) was about 13 percent in 1996 and 2004 (Table 12B-2 and Photo 12-13), although this level was lower than that seen in 1978. The dominant barnacle species was the small purple barnacle *Chthamalus dalli* in both 1996 and 2004 (8.4 percent cover in 2004), followed by the larger acorn barnacle *S. balanoides* (3.2 percent cover in 2004). The most abundant motile animals were littorine snails (*Littorina sitkana*, 73.6 per 0.25 square meter [m^2] in 2004; 237 per 0.25 m^2 in 1996), limpets (Lottiidae, 9 per 0.25 m^2 in 2004; 11.7 per 0.25 m^2 in 1996), the hairy hermit crab *P. hirsutiusculus*, and the drill *Nucella lima*. (Note that densities in Figure 12B-2 are reported as numbers per square meter.) Several species that were common in 1996 (e.g., the pulmonate gastropod *Siphonaria thersites*, the drill *Buccinum baeri*, and the sea star *Leptasterias hexactis*) were not observed in 2004.

The middle elevation at Knoll Head West is located across the crest of a low bedrock ridge (Photo 12-14) with moderate slope to the southeast ranging in elevation from about MLLW to +2 feet MLLW. With the aid of photographs, the transect to be sampled was laid out precisely along the line sampled in 1996; several individual quadrat markers from that survey were located again. A comparison of cover by major algal taxa, as measured in 1978, 1996, and 2004, is provided in Figure 12B-1. A dramatic shift in algal dominance occurred at this elevation between 1996 and 2004. In the 1970s and in 1996, the middle elevation was strongly dominated by red algae (primarily *Palmaria hecatensis* and *P. callophylloides*) which accounted for about 90 percent cover in 1996. Cumulative cover of *Palmaria* (all species) was only 46.4 percent in 2004. In contrast rockweed cover was 46.2 percent in 2004 compared with just 3.6 percent in 1996 and about 24 percent in September 1978. The resulting shift in dominance from red algae to brown algae is evident in the time sequence photographs of this transect taken over a span of 28 years (Photo 12-14).

Few animals were present at this elevation in 2004 or in any of the previous samples. Only the small grazing snail *Lacuna* was present in any substantial numbers in 2004 (187 per 0.25 m^2, Table 12B-2). A

substantial portion (nearly 15 percent) of the rock surface was covered with sessile animals in 2004 compared with less than 1 percent cover in 1996. The green sponge *Halichondria panicea* (9.6 percent) was dominant in 2004 followed by small barnacles (Figure 12B-2) and an encrusting bryozoan.

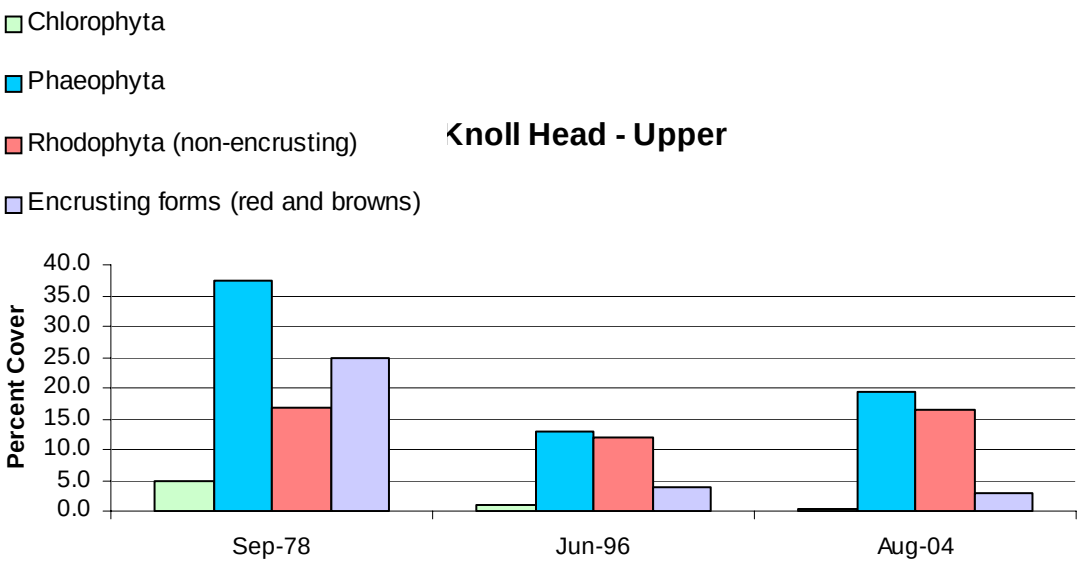
The lowest rock bench (-1 to -2.5 feet MLLW) at the Knoll Head West site, located adjacent to Port Site 2, was not sampled quantitatively. It consists of a mosaic of bedrock ridges, tide pools, and boulders (Photo 12-11). These diverse habitats support a much greater diversity of plants and especially of animals than is present at the middle or upper elevations. Multiple niches (epilithic, tide pool, under rock, in sediment) provided habitats for a variety of snails (*Trichotropis cancellata, Margarites pupillus, Lacuna*), sea stars (*Leptasterias* sp.*, Henricia leviuscula, H. tumida, H. sanguinolenta;* (e.g., Photo 12-15 taken at Port Site 2), and crustaceans (the hermit crabs *P. hirsutiusculus, P. beringanus, Elassochirus gilli*; sprontocarid shrimp). Sediment pockets in the tide pools included a number of large infauna including the deposit-feeding bivalves *Macoma balthica, M. inquinata*, and *Macoma obliqua*; the filter feeding bivalves *Protothaca staminea, Mya truncata*, and *Mya* sp.; polychaetes including *Nephtys* sp. and *Potamilla* sp.; and the burrowing echiurid *Echiurus echiurus*.

TABLE 12B-2
Macrobiota at Port Site 1a (Knoll Head West), August 2004.

Species	Upper Elevation (n=10)		Middle Elevation (n=10)		Species	Upper Elevation (n=10)		Middle Elevation (n=10)	
Plants (% cover)	**Mean**	**S.D.**	**Mean**	**S.D.**	**Animals (#/0.25 m^2)**	**Mean**	**S.D.**	**Mean**	**S.D.**
Acrosiphonia sp.	0.00	0.00	1.50	1.70	*Henricia tumida*	0.00	0.00	0.10	0.32
Analipus japonicus	0.15	0.34	0.00	0.00	*Lacuna* sp.	0.00	0.00	186.50	117.98
Ahnfeltia fastigiata	0.00	0.00	0.15	0.24	*Leptasterias* sp.	0.00	0.00	0.20	0.63
Corallina frondescens	0.05	0.16	0.00	0.00	*Littorina sitkana*	73.60	40.04	0.00	0.00
Corallina vancouveriensis	0.30	0.95	0.00	0.00	Lottidae	6.60	11.99	0.10	0.32
Cryptosiphonia woodii	0.00	0.00	0.50	0.94	Lottidae, juv.	0.00	0.00	0.10	0.32
Elachista fucicola	0.15	0.34	0.45	0.64	*Lottia pelta*	2.10	2.92	0.00	0.00
Elachista lubrica	0.00	0.00	0.10	0.32	*Nucella lima*	2.10	3.70	0.00	0.00
Encrusting coralline algae	0.80	1.14	0.20	0.42	*Pagurus hirsutiusculus*	2.90	3.07	0.20	0.42
Enteromorpha linza	0.30	0.95	0.00	0.00	*Tectura scutum*	0.30	0.48	0.20	0.63
Fucus gardneri	14.80	14.09	46.20	30.03	*Tonicella lineata*	0.00	0.00	0.20	0.63
Fucus gardneri, germlings	0.15	0.34	0.00	0.00					
Green crust	0.00	0.00	1.20	1.03	**Animals (% cover)**				
Halosaccion glandiforme	0.30	0.42	0.80	0.54	*Balanus* spp.	0.00	0.00	3.80	6.31
Hildenbrandia rubra	1.60	3.10	0.00	0.00	*Chthamalus dalli*	8.35	9.76	0.00	0.00
Leathesia difformis	0.05	0.16	0.00	0.00	*Chthamalus dalli,* set	0.05	0.16	0.00	0.00
Mastocarpus papillatus	0.00	0.00	0.35	0.67	*Halichondria panicea*	1.50	3.17	9.60	8.68
Mazzaella sp.	0.95	2.50	1.10	1.66	*Rhynchozoon bispinosum*	0.00	0.00	0.50	0.47
Neorhodomela oregona	13.85	17.72	0.00	0.00	*Semibalanus balanoides*	3.15	3.56	0.00	0.00
Palmaria callophylloides	0.00	0.00	5.00	6.63					
Palmaria hecatensis	0.00	0.00	41.40	19.83	**Dead Animals (%)**				
Porphyra aestivalis	0.45	0.64	0.75	0.79	*Balanus/Semibalanus*	0.25	0.63	0.00	0.00
Pterosiphonia bipinnata	0.40	0.66	0.55	0.96	*Chthamalus dalli*	0.20	0.35	0.00	0.00
Red crust	0.40	0.70	37.80	16.82	*Semibalanus balanoides*	0.15	0.24	0.00	0.00
Rhodomela tenuissima	0.00	0.00	0.10	0.21					
Soranthera ulvoidea	3.90	5.07	0.00	0.00					
Ulva/Ulvaria spp.	0.10	0.21	0.40	0.39					
Total algal cover	**38.70**	**25.74**	**138.55**	**29.09**					

Note: Colors correspond to colors in Figures 12B-1 and 12B-2.

FIGURE 12B-1
Abundance of Major Algal Groups at Knoll Head West—1978, 1996, and 2004



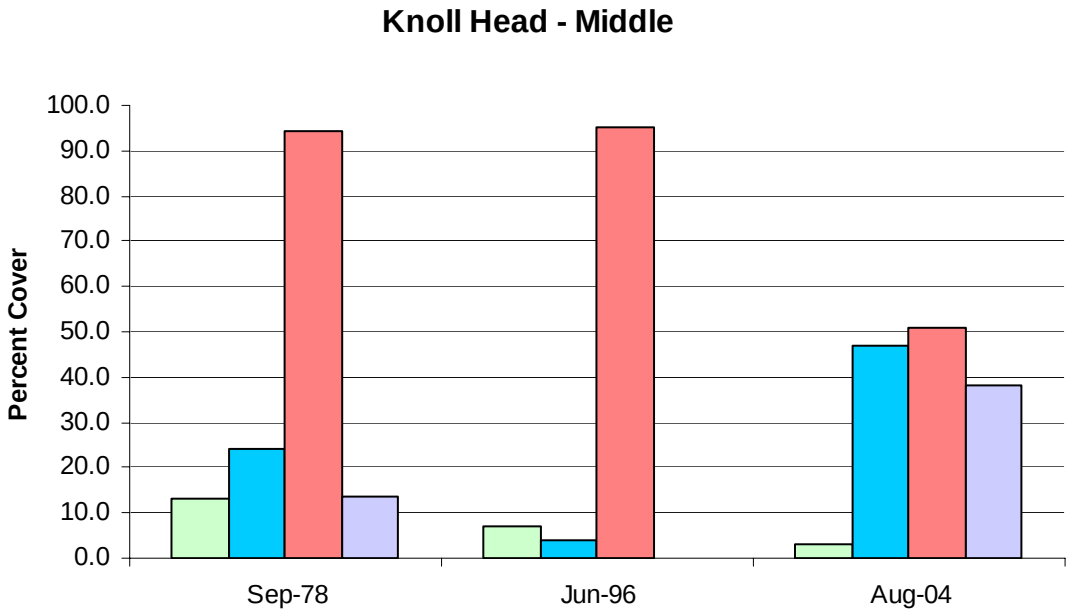
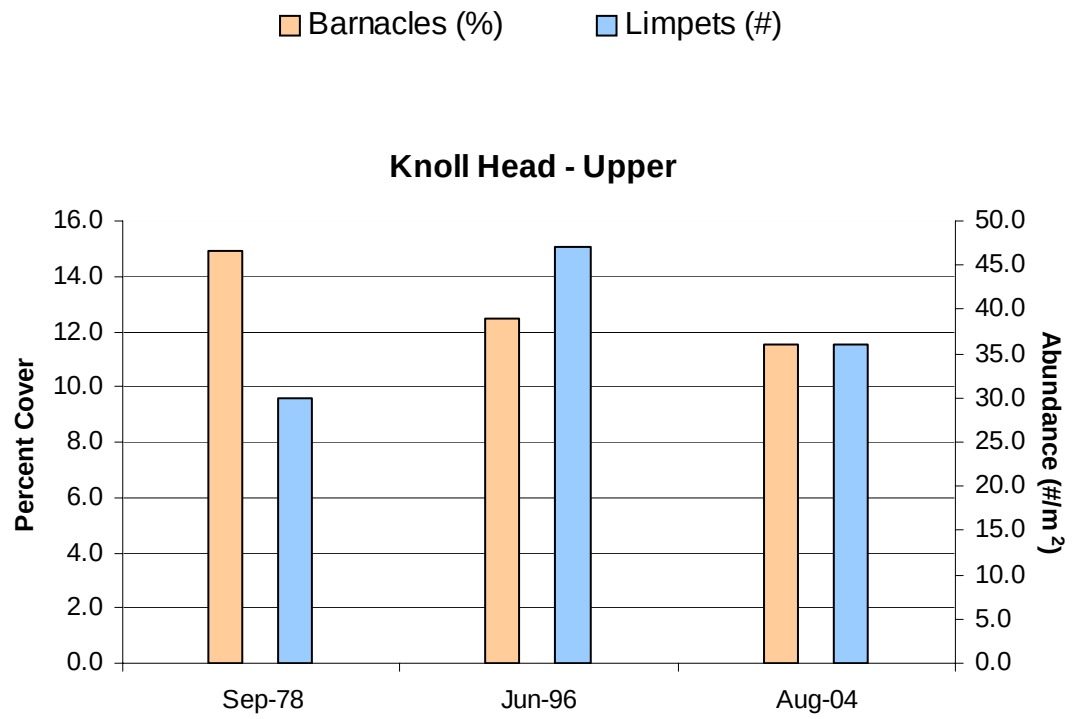
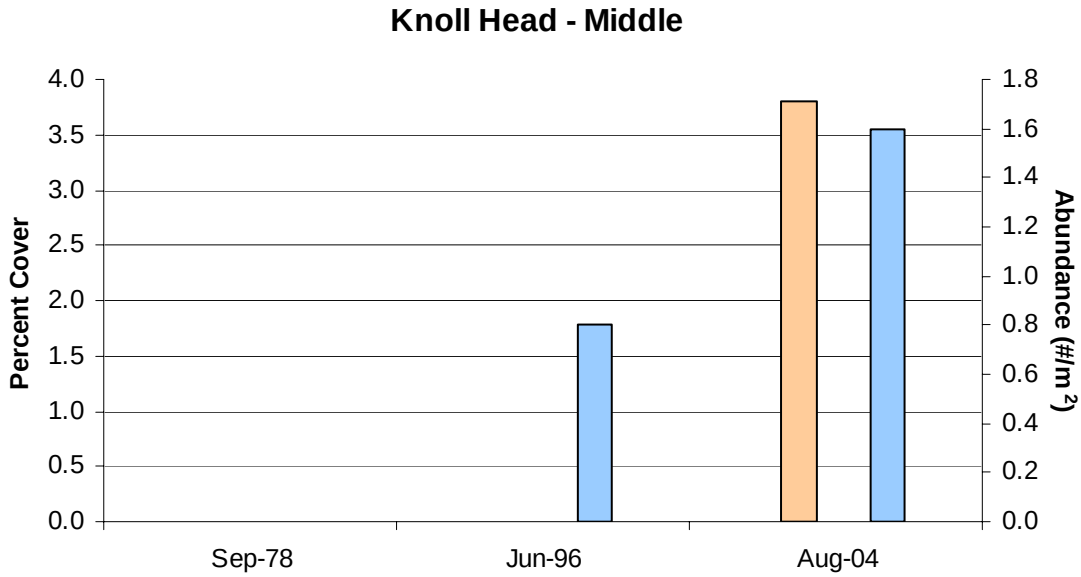


FIGURE 12B-2
Abundance of Dominant Fauna at Knoll Head West—1978, 1996, and 2004





12B.4 Port Site 2 (Southwest Iniskin Bay)

The shoreline at Port Site 2 is a mix of rock fall and bedrock at mid and upper intertidal elevations and fine mud at lower elevations (Figure 12-11 and Photo 12-4). The mudflat at this site is essentially the southern extremity of the vast mudflat that expands to the north across the entire inner two thirds of Iniskin Bay.

The highest intertidal zone consisted of steeply sloping bedrock supporting a biota typical of high-elevation rock around southcentral Alaska. The periwinkle snail, *Littorina sitkana*, limpets, and the barnacle *S. balanoides* were very abundant. Algae were not abundant, but there were some patches of rockweed and the red alga *N. oregona*. Isolated patches of mussels, *Mytilus trossulus*, were present mostly in protected crevices, and the drill *N. lima*, a major predator on mussels and barnacles, was common.

Quantitative sampling was accomplished on a relatively flat rock/shingle beach at the mid-tide elevation (+3.5 to +5 feet MLLW) beginning at the toe of the bedrock outcrop that formed the upper shoreline. The transect crossed a beach composed of slabs of rock forming a sort of pavement with interspersed patches of sand and tide pools (Photo 12-15). Both flora and fauna were compared to other mid-elevation transects. The dominant alga was the red *Neorhodomela oregona* (14.2 percent cover), and most of this was in tide pool areas. Total algal cover was only 16.7 percent (Table 12B-3). Sessile animals occupied about 10 percent of the rock surface with the small barnacle *C. dalli* the dominant species (8.6 percent cover). Motile animals were abundant relative to other mid-elevation rocky areas and included taxa that are common in sheltered middle elevations throughout southcentral Alaska (the periwinkle, limpets—Lottiidae, the drill *Nucella lima*, and the hairy hermit crab; Table 12B-3).

The only low-elevation rock at this site was provided by scattered boulders out on the mudflat. One large boulder at about -0.5 MLLW supported abundant barnacles (*S. balanoides*) and a few limpets, hermit crabs, and mussels. Algae on this boulder were mostly annuals, including the red laver (*Porphyra* spp.) and the green algae *Ulva* sp. and *Enteromorpha linza*.

TABLE 12B-3
Macrobiota at Port Site 2 (Southwest Iniskin Bay) Mid Elevation, August 2004

	Middle Elevation (n=5)	
Species	**Mean**	**S.D.**
Plants (% cover)		
Fucus gardneri	0.10	0.22
Hildenbrandia rubra	0.10	0.22
Neorhodomela oregona	14.20	15.02
Pterosiphonia bipinnata	1.80	2.49
Soranthera ulvoida	0.50	0.35
Total algal cover	**16.70**	**14.71**
Animals (#/0.25 m^2)		
Littorina sitkana	51.80	28.10
Lottidae	27.00	16.45
Nucella lima	9.20	11.34
Pagurus hirsutiusculus	11.80	17.04
Abarenicola (casts)	1.00	0.71
Pholidae	0.40	0.55
Animals (% cover)		
Balanus crenatus	0.20	0.45
Balanus rostratus	0.10	0.22
Balanus/Semibalanus spp.	0.50	0.35
Chthamalus dalli	8.60	6.88
Semibalanus balanoides	0.20	0.45
Nucella eggs	0.20	0.27

12B.5 Port Site 3 (Diamond Point)

This site was sampled on the rocky bench at the north entrance to Cottonwood Bay from Iliamna Bay (Figure 12-11 and Photo 12-16). Two elevations were sampled.

The middle transect wound through a bedrock saddle in the midst of the rock bench and thus had highly varied exposure. Elevation ranged from about +3 to +5 feet MLLW. Algae were relatively abundant at this elevation with 63 percent total cover (Table 12B-4). Rockweed was the dominant alga (38.2 percent), followed by *N. oregona* (9.7 percent) and *N. aculeata* (5.8 percent). Cover by sessile animals was also high (over 40 percent) and was dominated by the barnacles *S. balanoides* and *C. dalli.* Motile animals were numerically dominated by the periwinkle *L. sitkana* (174 per 0.25 m^2, Table 12B-4), followed by limpets (18.6 per 0.25 m^2), drills (*N. lima*, 14 per 0.25 m^2), and hairy hermit crabs (6.5 per 0.25 m^2).

The lower-elevation transect at Diamond Point wrapped around the lower rock face at about -1.5 to -0.5 feet MLLW, just above where rock substrates meet a mixed soft-sediment flat. Exposure is to the south. The rock was covered with a thin veneer of silt. Algae were moderately abundant here and dominated by rockweed (15.3 percent cover), encrusting reds (over 10 percent), and the red *P. callophylloides* (7.5 percent). Kelps, typically dominant on low rock, were conspicuously absent. Sessile animals were relatively abundant for a low rocky habitat, possibly reflecting a dearth of predatory sea stars and drills. Barnacles occupied nearly 20 percent of the substrate, and the green sponge *H. panicea* also was widespread (9 percent cover, Table 12B-4). Motile animals were less abundant with only 3.3 hairy hermit crabs per 0.25 m^2, and 1.1 *Lacuna* and 1.1 limpets per 0.25 m^2.

TABLE 12B-4
Macrobiota on Rocky Substrata at Port Site 3 (Diamond Point), August 2004

Species	Mid Elevation (n=10)		Lower Elevation (n=10)		Species	Mid Elevation (n=10)		Lower Elevation (n=10)	
	Mean	S.D.	Mean	S.D.		Mean	S.D.	Mean	S.D.
Plants (% cover)					**Animals (#/0.25 m^2)**				
Acrosiphonia sp.	0.15	0.34	0.80	1.60	*Clinocardium nuttallii*	0.00	0.00	0.10	0.32
Ceramium cimbricum	0.05	0.16	0.25	0.35	*Gammaridea*	0.05	0.16	present not counted	
Chaetomorpha	0.30	0.95	0.00	0.00	*Lacuna* spp.	0.10	0.32	1.10	2.51
Cryptosiphonia woodii	0.10	0.32	0.00	0.00	*Leptasterias*	0.00	0.00	0.10	0.32
Elachista fucicola	0.00	0.00	0.60	1.24	*Littorina sitkana*	174.30	82.29	0.00	0.00
Encrusting coralline algae	1.10	1.85	0.00	0.00	*Littorina sitkana* egg cases	0.10	0.32	0.00	0.00
Encrusting red algae	0.00	0.00	6.00	10.14	Lottidae	18.60	10.16	1.10	2.60
Enteromorpha linza	0.00	0.00	0.40	0.94	*Lottia pelta*	0.40	0.52	0.00	0.00
Fucus gardneri	38.20	22.30	15.25	16.95	*Nucella lima*	14.00	11.17	0.10	0.32
Fucus gardneri, germlings	0.00	0.00	0.15	0.24	*Pagurus hirsutiusculus*	6.50	10.06	3.30	2.36
Halosaccion glandiforme	0.65	1.56	0.00	0.00	*Pholid/Stuhard*	0.10	0.32	0.00	0.00
Hildenbrandia rubra	0.75	1.32	0.00	0.00	*Tectura persona*	0.10	0.32	0.00	0.00
Leathesia difformis	0.05	0.16	0.00	0.00	*Tectura scutum*	0.00	0.00	0.20	0.42
Mazzaella sp.	0.80	1.32	1.10	1.65	*Tonicella lineata*	0.10	0.32	0.00	0.00
Neorhodomela aculeata	5.80	12.55	0.00	0.00					
Neorhodomela oregona	9.70	13.07	0.00	0.00	**Animals (% cover)**				
Palmaria callophylloides	0.30	0.95	7.50	9.42	*Balanus crenatus*	0.05	0.16	3.40	6.29
Palmaria hecatensis	0.00	0.00	1.55	2.93	*Chthamalus dalli*	8.95	9.93	1.40	1.70
Polysiphonia/Pterosiphonia	0.00	0.00	1.20	2.70	*Chthamalus dalli,* set	0.00	0.00	0.10	0.21
Polysiphonia pacifica	0.00	0.00	0.35	0.94	*Encrusting bryozoan*	0.00	0.00	0.40	1.26
Porphyra aestivalis	0.00	0.00	0.55	1.26	*Halichondria panicea*	0.80	2.53	9.00	18.25
Pterosiphonia bipinnata	0.45	0.96	0.30	0.67	*Semibalanus balanoides*	33.50	27.94	7.10	22.10
Ralfsia spp.	0.05	0.16	0.00	0.00	*Semibalanus balanoides*, set	0.00	0.00	8.35	25.18
Red crust	0.50	1.58	2.00	6.32					
Red film	0.00	0.00	5.80	9.65	**Dead Animals (%)**				
Rhodochorton purpureum	0.00	0.00	2.25	4.98	*Balanus/Semibalanus*	0.35	0.47	0.40	0.52
Soranthera ulvoida	3.80	6.52	0.00	0.00	*Chthamalus dalli*	0.20	0.42	0.00	0.00
Sphacelaria	0.00	0.00	1.15	3.13	*Semibalanus balanoides*	0.40	0.70	0.00	0.00
Ulva sp.	0.25	0.63	1.45	3.07					
Total algal cover	**63.00**	**26.02**	**48.65**	**43.97**					

12B.6 Port Site 4 (North Head)

The site sampled at Port Site 4 lay in a small bight on the west side of North Head (Figure 12-2). The upper pocket-beach of pebble-sized gravel was contained to the west by a rocky outcrop (Photo 12-6). The middle and lower elevations consisted of a boulder-cobble substrate set in a sandy matrix. Both middle and lower elevations were sampled quantitatively.

Upper elevations on the bedrock outcrop that defined the west end of the gravel beach were not sampled quantitatively. However, this area supported a high cover (to 80 percent) of the barnacle *S. balanoides*, with two size classes present. Also present, especially in crevices in the rock, were mussels, drills, limpets, and sea stars (*Leptasterias*). Scattered algae included the green *Ulva* sp. and the red *Porphyra aestivalis*, both annuals. At somewhat lower elevations and in shadier areas the green sponge *Halicondria* was also found along with the red algae *Halosaccion glandiforme*.

The middle elevation sampled was at about +2 feet MLLW, just below the lower edge of the gravel beach (Photo 12-17). Algal cover was moderate (39 percent overall; Table 12B-5) and included a mix of browns, reds, and greens. Rockweed was the dominant species (16.2 percent) followed by a red (*P. callophylloides*, 5.0 percent), encrusting reds (4.8 percent), and the greens *Ulva* sp. and *Acrosiphonia* sp. Animal cover on rock surfaces at the mid elevation was low and was dominated by the green sponge (3.7 percent cover—mostly under overhanging edges of boulders), with limited numbers of barnacles (less than 2 percent for all species). Motile animal numbers were very low with no taxon exceeding one per 0.25 m^2.

The lower-elevation transect sampled was at an elevation of about -1 foot MLLW. Algae were somewhat more abundant than at the mid elevation and generally followed the same pattern of rockweed dominance (27.7 percent cover) followed by the same mix of reds and greens that was seen at the middle elevation (Table 12B-5). *Palmaria hecatensis* was more abundant than *P. callophylloides*, and laminarian kelp was somewhat more abundant than at the mid elevation. Barnacle cover was also higher at the lower elevation (about 5 percent for all species) and included a few newly set thatched barnacles, *Semibalanus cariosus*; otherwise there were only limited numbers of sessile animals. The small snail *Lacuna* was the only motile animal with more than one individual per 0.25 m^2.

A single excavation of an approximately 1/16-m^2 area in the lower sandy matrix at about -1 foot MLLW yielded nine larger *Macoma* and two to three *Nephtys*, a large pink gammarid amphipod, and a gunnel (Pholidae).

TABLE 12B-5
Macrobiota on Boulder/Rock Substrata at Port Site 4 (North Head)

Species	Middle Elevation (n=10)		Lower Elevation (n=10)		Species	Middle Elevation (n=10)		Lower Elevation (n=10)	
	Mean	S.D.	Mean	S.D.		Mean	S.D.	Mean	S.D.
Plants (% cover)					**Animals (#/0.25 m^2)**				
Acrosiphonia sp.	2.15	3.00	5.45	5.80	*Haliclystus*	0.00	0.00	0.10	0.32
Articulated coralline algae	0.00	0.00	0.30	0.67	*Lacuna* spp.	0.50	1.58	12.10	16.86
Desmarestia aculeata	0.00	0.00	0.10	0.32	*Leptasterias* sp. (juv.)	0.00	0.00	0.10	0.32
Diatoms	1.00	1.68	1.25	1.44	Lottiidae, juv.	0.00	0.00	0.10	0.32
Diatom film	2.90	4.33	3.30	5.58	Lottiidae	0.30	0.95	0.00	0.00
Elachista fucicola	0.35	0.67	0.05	0.16	*Pagurus hirsutiusculus*	0.50	0.53	0.50	0.71
Encrusting coralline algae	0.00	0.00	0.10	0.32	*Pagurus beringanus*	0.00	0.00	0.10	0.32
Encrusting red algae	4.80	6.12	5.60	5.72	*Pholis* sp.	0.10	0.32	0.00	0.00
Enteromorpha linza	1.75	3.14	0.80	1.53	*Tectura scutum*	0.00	0.00	0.10	0.32
Fucus gardneri	13.00	11.92	27.70	19.22					
Fucus gardneri, germlings	3.20	6.10	0.00	0.00	**Animals (% cover)**				
Halosaccion firmum	0.10	0.32	0.15	0.34	*Balanus crenatus*	0.00	0.00	0.05	0.16
Laminaria groenlandica	0.00	0.00	0.40	1.26	*Balanus* spp.	0.00	0.00	2.50	5.40
Laminaria, juv.	0.75	2.20	0.20	0.26	*Balanus/Semibalanus,* set	1.20	1.30	2.30	3.59
Laminaria sp.	0.05	0.16	1.70	3.95	*Chthamalus dalli*	0.50	1.27	0.00	0.00
Mazzaella sp.	0.50	1.08	1.50	1.90	*Chthamalus dalli,* set	0.00	0.00	0.30	0.35
Neorhodomela oregona	0.05	0.16	0.00	0.00	Encrusting bryozoan	0.05	0.16	0.35	0.94
Odonthalia kamschatica?	0.00	0.00	0.05	0.16	*Garveia*	0.00	0.00	0.05	0.16
Palmaria callophylloides	4.95	6.57	2.75	2.90	*Halichondria panicea*	3.65	5.11	0.10	0.32
Palmaria hecatensis	1.05	1.38	5.80	7.77	Hydroids % (? *Garveia* sp.)	0.00	0.00	0.90	1.07
Palmaria mollis	0.20	0.63	0.10	0.32	*Rhynchozoon bispinosum*	0.30	0.95	0.00	0.00
Phycodrys riggii	0.00	0.00	0.80	1.32	*Semibalanus balanoides*	0.20	0.35	0.00	0.00
Polysiphonia spp.	0.00	0.00	0.25	0.42	*Semibalanus cariosus,* set	0.00	0.00	0.15	0.24
Porphyra cuneiformis	0.10	0.32	0.35	0.67					
Ulva sp.	2.40	2.91	1.10	1.07	**Dead Animals (%)**				
Phyllophoraceae unid.	0.00	0.00	0.70	1.64	*Semibalanus balanoides*	0.15	0.24	0.00	0.00
Sphacelaria rigidula	0.00	0.00	0.10	0.32					
Total algal cover	**39.30**	**17.59**	**60.60**	**18.72**					

12B.7 Scott Island

Like Port Site 1a (Knoll Head), Scott Island (Figure 12-11) was sampled in the 1970s (Lees et al., 1980) and in 1996 (Pentec, 1996). This site (Photo 12-8) was included in the study as a potential reference site, expected to be removed from project influences. Three elevations were sampled at Scott Island, all primarily on bedrock, although the low-elevation transect included a shallow tide pool. With the aid of photographs, the three transects to be sampled were laid out precisely along the lines sampled in 1996. Transect head stakes and several individual quadrat markers from that survey were located again.

The upper elevation sampled lies on a relatively flat bedrock bench at approximately +6 to +7 feet MLLW (Photo 12-18). A comparison of abundance of major algal taxa, as measured in September 1978, June 1996, and September 2004, is provided in Figure 12B-3. Bedrock at this elevation had 50 percent more algal cover in 2004 (90.6 percent; Table 12B-6) than in 1996 (60.7 percent), with much of the increase due to greater cover by rockweed (37 percent in 2004 vs. 22.2 percent in 1996, Photo 12-19) and an epiphytic alga (*Soranthera ulvoidea*, 8.25 percent in 2004 and 0.3 percent in 1996). In contrast, animal cover was much greater in 1978 and 1996 than in 2004, with the primary difference being in the greater abundance of barnacles (3 percent in 2004 and 14.2 percent in 1996, Figure 12B-4). Motile animal numbers were strongly dominated by the periwinkle (*L. sitkana*) in all years. The next most abundant species in 1996, the pulmonate *Siphonaria* (19.9 per 0.25 m^2), was common from April through September 1978, but was absent in 2004. Limpets were also considerably more abundant in September 1978 and June 1996 than in early September 2004 (Figure 12B-4).

The mid-elevation head stake lies at about +1 foot MLLW, but the transect ascends and wraps east around a smooth, sloping bedrock face such that the elevations actually sampled lie at about +3 to +4 feet MLLW (Photo 12-20). A comparison of abundance of major algal taxa, as measured in 1978, 1996, and 2004, is provided in Figure 12B-3. Rock at this elevation is covered by multiple layers of algae such that total coverage was 141 percent in 2004 (Table 12B-6; 98.4 percent in 1996). In 2004, rockweed was the dominant species at 58.8 percent, compared to 11 percent in 1978 and only 3.7 percent in 1996. Red algae, especially three species of *Palmaria*, were strongly dominant in June of 1978 (88.7 percent) and 1996 (88.0 percent), but contributed only 63.4 percent cover in early September 2004. This change in species composition from one dominated by *Palmaria* spp. to one dominated by rockweed suggests that the site has been less disturbed by ice scour in recent years compared to the period up to 1996. Cover of the rock substrate by sessile animals was low in all years. The green sponge *Halichondria* was the only species exceeding 1 percent cover in all years (7.1 percent cover in 2004, 2.4 percent in 1996, and 2.5 percent in 1978; Figure 12B-4). The barnacle *B. crenatus* also exceeded 1 percent cover in 2004, but no barnacles were recorded in earlier sampling. Herring eggs were found on the red algae at this site in June 1996. Motile organisms were not abundant in any of the survey years, with *Lacuna* the most abundant species in 2004 (7.5 per 0.25 m^2), and no other species exceeding one per 0.25 m^2 in any year. Limpets, which had been quite abundant in 1978 (4.7 per m^2), declined to less than 1 per m^2 in 1996 and were absent in 2004 (Figure 12B-4).

The lower-elevation transect crosses a low rocky swale at about -1 foot MLLW; a broad shallow tide pool occupies about half of the transect length (Photo 12-21). Total algal cover was high in 2004 (110 percent cover, Table 12B-6) and 1978, but was even higher in 1996 (Figure 12B-3). Lower algal cover in 1978 and 2004 may be the result of sampling later in these years compared to the June 1996 sampling. In all

years, this elevation was dominated by kelp (especially *Laminaria* spp.), which typically reach their greatest cover in late spring. Similarly, ribbon kelp (*Alaria* sp.) had 13 percent cover in June 1996, but was poorly represented in September 2004 (2 percent). The red algae *Palmaria* spp. and the green alga *Ulva* sp. were common in all years. The lower transect at Scott Island had relatively little animal cover in 1996 (Figure 12B-4), with herring eggs being the only taxa exceeding 1 percent. Several taxa were somewhat more abundant in 2004 than in the earlier sampling, with both an encrusting bryozoan (Bryozoa) and encrusting sponges (Porifera) exceeding 1 percent cover. Motile species were not abundant in any year, but the small snail *Lacuna* was markedly more abundant in 2004 (34.4 per 0.25 m^2). The lined chiton *Tonicella lineata* (Figure 12B-4) and the horse mussel *Modiolus modiolus* were both between 4 and 14 per m^2 in both years.

Small schools of both juvenile and adult Pacific sand lance and several adult greenling (*Hexagrammos* sp.) were seen in larger tide pools and areas off of rocky benches at low tide (e.g., about -2 feet MLLW).

TABLE 12B-6
Macrobiota on rocky substrata at Scott Island—September 2004.

	Upper Elevation (n=8)		Middle Elevation (n=8)		Lower Elevation (n=5)	
Species	**Mean**	**S.D.**	**Mean**	**S.D.**	**Mean**	**S.D.**
Plants (% cover)						
Acrosiphonia sp.	0.00	0.00	0.00	0.00	0.50	0.87
Acrosiphonia areta	0.00	0.00	0.06	0.18	0.00	0.00
Alaria taeniata	0.00	0.00	0.00	0.00	2.00	4.47
Constantinea subulifera	0.00	0.00	0.00	0.00	0.60	1.34
Corallina frondescens	0.00	0.00	0.00	0.00	1.60	2.04
Corallina officinalis	0.00	0.00	0.00	0.00	0.20	0.45
Cryptosiphonia woodii	0.00	0.00	0.19	0.26	0.00	0.00
Elachista fucicola	0.06	0.18	4.63	2.62	0.20	0.45
Encrusting coralline algae	0.00	0.00	0.31	0.70	10.20	11.45
Encrusting green algae	1.25	3.54	1.00	1.51	0.20	0.45
Encrusting red algae *(Hildenbrandia?)*	27.50	14.39	7.75	9.81	0.00	0.00
Enteromorpha linza	2.50	7.07	0.88	1.69	1.50	2.12
Fucus gardneri	37.50	28.58	58.75	19.23	11.00	14.68
Fucus gardneri, germlings	0.06	0.18	0.13	0.35	1.00	2.24
Green crust	0.00	0.00	1.25	2.31	0.00	0.00
Halosaccion glandiforme	0.13	0.23	1.44	0.94	1.70	1.20
Hildenbrandia rubra	0.00	0.00	0.25	0.71	0.00	0.00
Laminaria groenlandica	0.00	0.00	0.00	0.00	31.00	28.81
Leathesia difformis	0.00	0.00	0.00	0.00	0.40	0.89
Mastocarpus papillatus	2.13	1.96	0.00	0.00	1.80	3.03
Mazzaella sp.	0.06	0.18	7.13	4.22	3.50	3.46
Monostroma grevillei	0.00	0.00	0.13	0.23	0.00	0.00
Neodilsea borealis	0.00	0.00	0.00	0.00	0.80	1.79
Neorhodomela aculeata	0.00	0.00	0.25	0.71	0.00	0.00
Neorhodomela oregona	11.06	10.92	0.00	0.00	0.30	0.45
Palmaria callophylloides	0.00	0.00	24.00	17.82	5.20	3.83
Palmaria hecatensis	0.00	0.00	28.13	4.05	21.40	28.01

	Upper Elevation (n=8)		Middle Elevation (n=8)		Lower Elevation (n=5)	
Species	**Mean**	**S.D.**	**Mean**	**S.D.**	**Mean**	**S.D.**
Phycodrys riggii	0.00	0.00	0.00	0.00	1.00	1.41
Pilayella littoralis	0.00	0.00	0.13	0.35	0.00	0.00
Porphyra aestivalis	0.00	0.00	2.00	3.41	0.00	0.00
Pterosiphonia bipinnata	0.06	0.18	0.25	0.71	0.20	0.45
Ralfsia fungiformis	0.00	0.00	0.00	0.00	0.40	0.89
Ralfsia sp.	0.00	0.00	0.00	0.00	0.20	0.45
Red Crust	0.00	0.00	1.00	1.60	1.60	3.58
Soranthera ulvoida	8.25	8.68	0.00	0.00	0.00	0.00
Ulva sp.	0.00	0.00	1.19	1.31	12.20	5.59
Total algal cover	**90.56**	**32.60**	**140.81**	**16.07**	**110.70**	**23.07**
Animals (#/0.25 m^2)						
Anthophleura artemisia	0.00	0.00	0.00	0.00	1.00	1.73
Lacuna spp.	1.88	5.30	7.50	8.96	34.40	41.16
Leptasterias	0.00	0.00	0.13	0.35	0.60	0.89
Littorina sitkana	40.00	32.54	0.00	0.00	0.00	0.00
Lottidae	0.75	0.71	0.00	0.00	0.20	0.45
Margarites pupillus (spiral)	0.00	0.00	0.00	0.00	0.20	0.45
Modiolus modiolus	0.00	0.00	0.00	0.00	1.20	2.68
Mya sp.	0.00	0.00	0.00	0.00	0.20	0.45
Nucella lima	0.00	0.00	0.13	0.35	0.00	0.00
Pagurus hirsutiusculus	3.13	4.64	0.88	1.13	1.00	1.00
Pagurus beringanus	0.00	0.00	0.00	0.00	0.40	0.55
Paranemertes peregrina	0.00	0.00	0.00	0.00	0.20	0.45
Pugettia gracilis	0.00	0.00	0.13	0.35	0.20	0.45
Shrimp	0.00	0.00	0.00	0.00	0.40	0.89
Tonicella lineata	0.00	0.00	0.00	0.00	3.60	1.82
Animals (% cover)						
Balanus crenatus	0.00	0.00	1.56	1.08	0.60	0.55
Balanus/Semibalanus spp.	0.00	0.00	0.00	0.00	0.20	0.27
Balanus/Semibalanus set	0.06	0.18	0.00	0.00	0.00	0.00
Chthamalus dalli	1.81	1.07	0.00	0.00	0.20	0.27
Garveia sp.	0.00	0.00	0.00	0.00	0.50	0.35
Encrusting bryozoan	0.00	0.00	0.13	0.35	1.00	1.41
Halichondria panicea	0.00	0.00	7.13	6.64	0.20	0.45
Orange sponge, ever	0.00	0.00	0.00	0.00	1.00	1.70
Pugettia gracilis	0.00	0.00	0.00	0.00	0.20	0.45
Semibalanus balanoides	1.13	0.92	0.25	0.27	0.00	0.00
Spirobidae, unid.	0.00	0.00	0.00	0.00	0.20	0.27
Dead Animals (%)						
Balanus crenatus	0.00	0.00	0.00	0.00	0.20	0.45
Balanus/Semibalanus	0.19	0.37	0.00	0.00	0.00	0.00
Chthamalus dalli	0.25	0.46	0.00	0.00	0.00	0.00

Note: Colors correspond to colors in Figures 12B-3 and 12B-4.

FIGURE 12B-3
Abundance of Major Algal Groups at Scott Island; 1978, 1996, and 2004

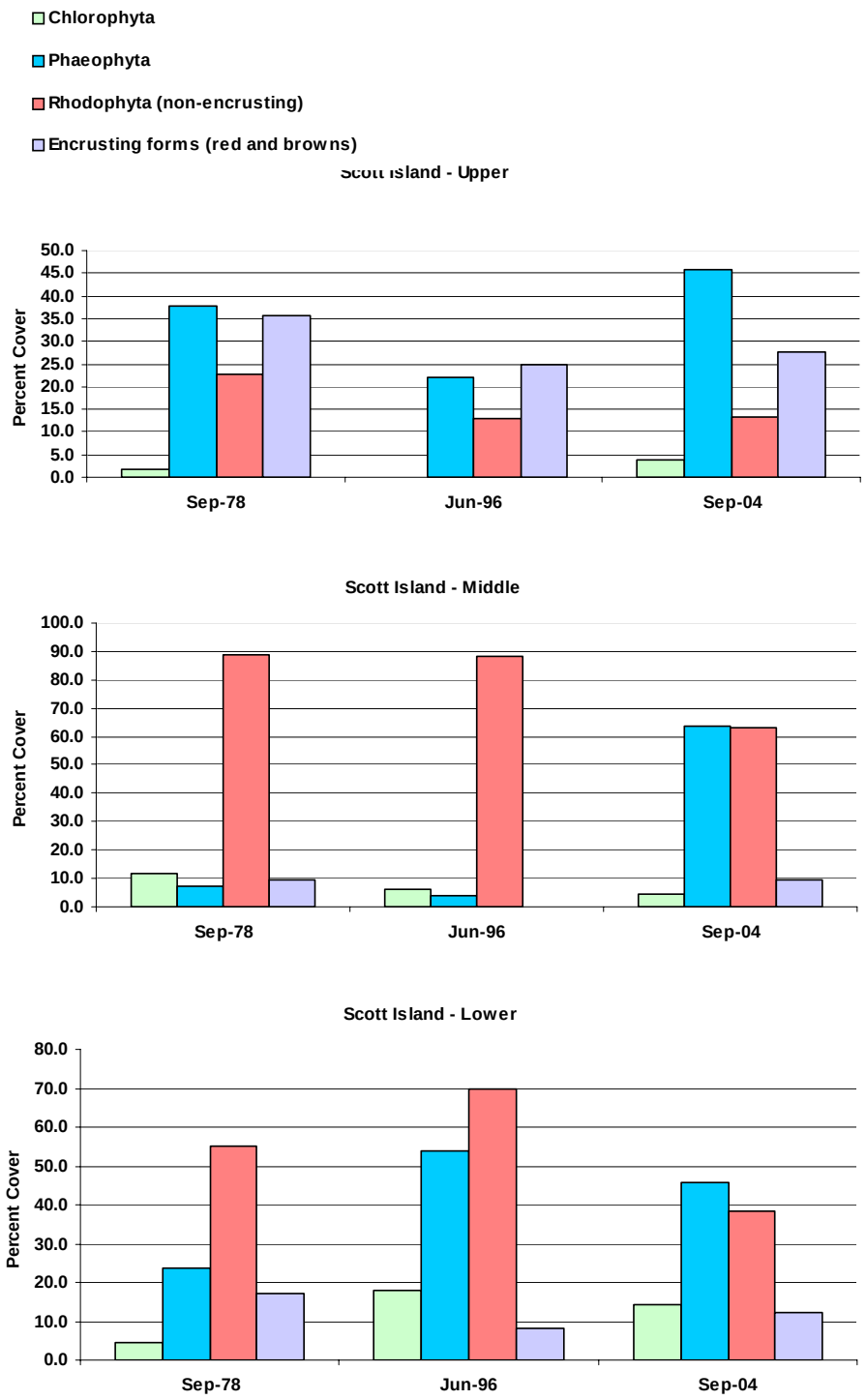
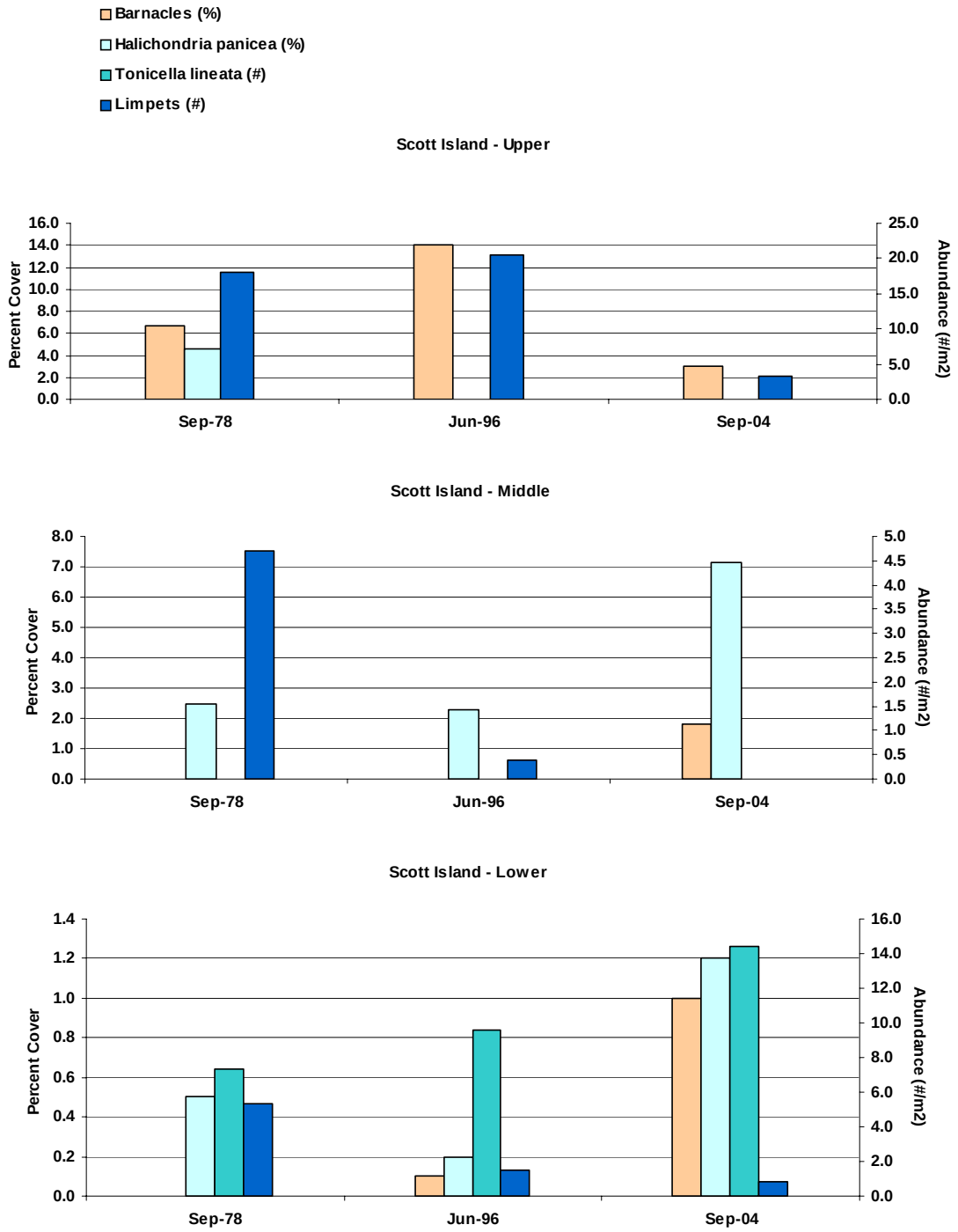


FIGURE 12B-4
Abundance of Dominant Fauna at Scott Island; 1978, 1996, and 2004



APPENDIX 12-C
Subtidal Diver Transects

TABLE 12C-1
Benthic reconnaissance dive survey of algae, epifaunal invertebrates, and fishes from marine Port Site 1, off Knoll Head, Iniskin Bay, August 29, 2004, Transect 1 of 2.

Site Transect Name:	Port Site 1, Transect 1 of 2
Time:	1008-1100
Tidal Height (ft re: MLLW):	-1.2 to -1.4
Actual Depth (ft):	10 - 51
Adjusted Depth (ft re: MLLW):	11.2 - 49.6
Transect Distance (ft):	777
Substrate:	Mixed sand/silt over gravel
Visibility (ft):	4-5 @ 10 ft to 2 @ 51 ft.
Tidal state:	Slight flood
Divers:	S. Jewett/H. Chenelot
TAXON	**COMMON NAME**
PORIFERA	
Suberites sp.	Sponge
CNIDARIA	
Hydrozoa—*Sertulariidae*	Hydroid
Anthozoa—*Urticina crassicornis*	Sea anemone
ANNELIDA—Polychaeta	
Potamilla sp.	Polychaete
Schizobranchia insignis?	Polychaete
MOLLUSCA—Gastropoda	
Margarites pupillus	Snail
Fusitriton oregonensis	Snail
Neptunea lyrata	Snail
Thais lamellosa	Snail
Onchidoris bilamellata	Nudibranch
MOLLUSCA—Polyplacophora	
Molpadia sp.	Chiton
Cryptochiton stelleri	Chiton
Ischnochiton sp.	Chiton
ARTHROPODA—Crustacea	
Unidentified shrimp	Shrimp
Pagurus beringanus	Hermit crab
Elassochirus tenuimanus	Hermit crab
E. gilli	Hermit crab

TABLE 12C-1 CONT'D
Benthic reconnaissance dive survey of algae, epifaunal invertebrates, and fishes from marine Port Site 1, off Knoll Head, Iniskin Bay, August 29, 2004, Transect 1 of 2.

TAXON	COMMON NAME
ARTHROPODA—Crustacea (Cont'd)	
Rhinolithodes wosnessenskii	Umbrella crab
Telmessus cheiragonus	Helmet crab
Hyas lyratus	Lyre crab
Oregonia gracilis	Decorator crab
Pugettia gracilus	Kelp crab
ECTOPROCTA	
Flustrellidae	Bryozoan
ECHINODERMATA—Asteroidea	
Henricia leviuscula	Blood sea star
Leptasterias sp.	Sea star
Leptasterias polaris acervata	Sea star
Leptasterias alaskensis	Sea star
Crossaster papposus	Sea star
CHORDATA—Pisces	
Hexagrammos stelleri	Whitespotted greenling
Stichaeus punctatus	Arctic shanny
Pleuronectidae (juvenile.)	Flatfish

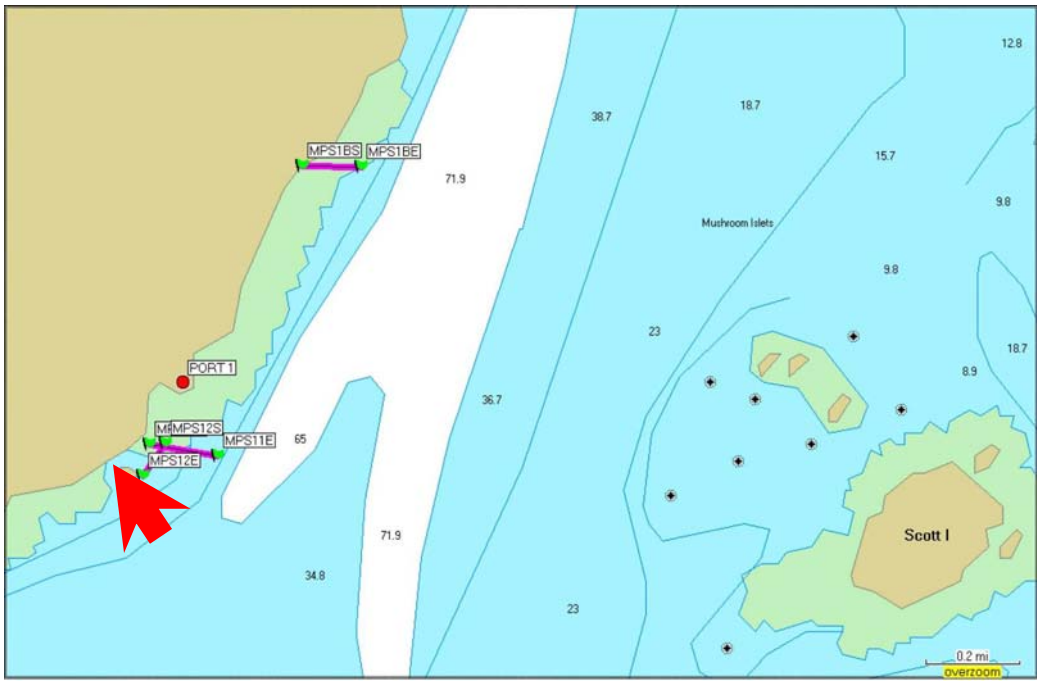
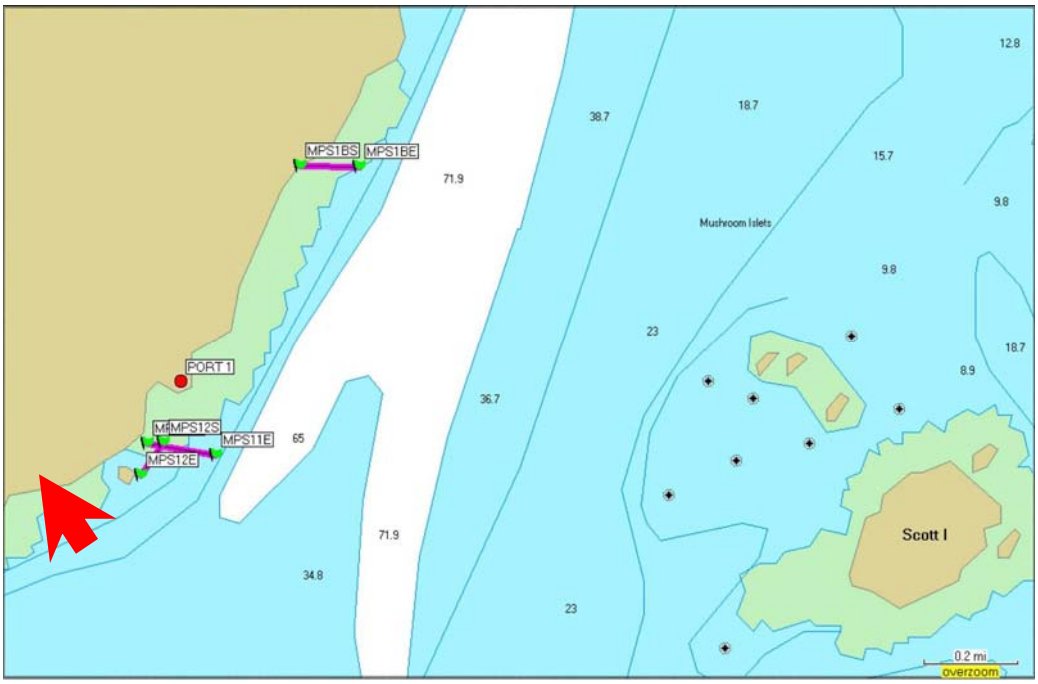


TABLE 12C-2
Benthic reconnaissance dive survey of algae, epifaunal invertebrates, and fishes from marine Port Site 1, off Knoll Head, Iniskin Bay, August 29, 2004, Transect 2 of 2.

Site Transect Name:	Port Site 1, Transect 2 of 2
Time:	1435-1509
Tidal Height (ft re: MLLW):	+15.1 to +15.8
Actual Depth (ft):	32 - 31
Adjusted Depth (ft re: MLLW):	16.9 - 15.2
Transect Distance (ft):	437
Substrate:	Gravel
Visibility (ft):	2
Tidal state:	Strong flood
Divers:	S. Jewett/H. Chenelot

TAXON	**COMMON NAME**
ALGAE—Rhodophyta	Red algae
Coralline	Encrusting coralline algae
PORIFERA	
Suberites sp.	Sponge
ANNELIDA—Polychaeta	
Schizobranchia insignis?	Polychaete
MOLLUSCA—Pelecypoda	
Pododesmus macroschisma	Rock jingle
MOLLUSCA—Gastropoda	
Fusitriton oregonensis	Snail
Neptunea lyrata	Snail
MOLLUSCA—Polyplacophora	
Cryptochiton stelleri	Chiton
Tonicella lineata	Chiton
Tonicella insignis	Chiton
Mopalia ciliata	Chiton
ARTHROPODA—Crustacea	
Balanus glandula	Barnacle
Pagurus sp.	Hermit crab
Cancer oregonensis	Cancer crab
Hyas lyratus	Lyre crab
Pugettia gracilus	Kelp crab
ECTOPROCTA	
Flustrellidae	Bryozoan
ECHINODERMATA—Asteroidea	
Lepasterias sp.	Sea star
Henricia leviuscula	Blood sea star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MPS1BE
PORT 1
MPS12S
MPS11E
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12.8
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Mushroom Islets
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23
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65
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TABLE 12C-3
Benthic reconnaissance dive survey of algae, epifaunal invertebrates, and fishes from marine Port Site 1b (midpoint between Port Sites 1 and 2), Iniskin Bay, August 31, 2004

Site Transect Name:	Port Site 1b
Time:	1255-1314
Tidal Height (ft re: MLLW):	+4.6 to +6.2
Actual Depth (ft):	3 - 17
Adjusted Depth (ft re: MLLW):	+1.6 - 10.8
Transect Distance (ft):	667
Substrate:	Sand/silt/gravel throughout
Visibility (ft):	3 @ shallow; 1 @ deep
Tidal state:	Very strong flood
Divers:	S. Jewett/S. Harper
TAXON	**COMMON NAME**
ALGAE—Chlorophyta	Green algae
Ulva sp.	Sea lettuce
ALGAE—Phaeophyta	Brown algae
Laminaria bongardiana	Split kelp
Fucus gardneri	Bubble kelp
ALGAE—Rhodophyta	Red algae
PORIFERA	
Suberites sp.	Sponge
ANNELIDA—Polychaeta	
Schizobranchia insignis?	Polychaete
MOLLUSCA—Pelecypoda	
Mytilus trossulus	Blue mussel
iMactromerus polynyma	Pinkneck clam
Clinocardium nuttalli	Cockle
MOLLUSCA—Gastropoda	
Tectura scutum	Snail
Nucella lima	Snail
Onchidoris bilamellata	Nudibranch
ARTHROPODA—Crustacea	
Pagurus sp.	Hermit crab
Pagurus ochotensis	Hermit crab
P. hirsutiusculus	Hermit crab
P. aleuticus	Hermit crab
ARTHROPODA—Crustacea (Cont'd)	
P. beringanus	Hermit crab
Telmessus cheiragonus	Helmet crab
ECTOPROCTA—Flustrellidae	Bryozoan
ECHINODERMATA—Asteroidea	
Leptasterias alaskensis	Sea star

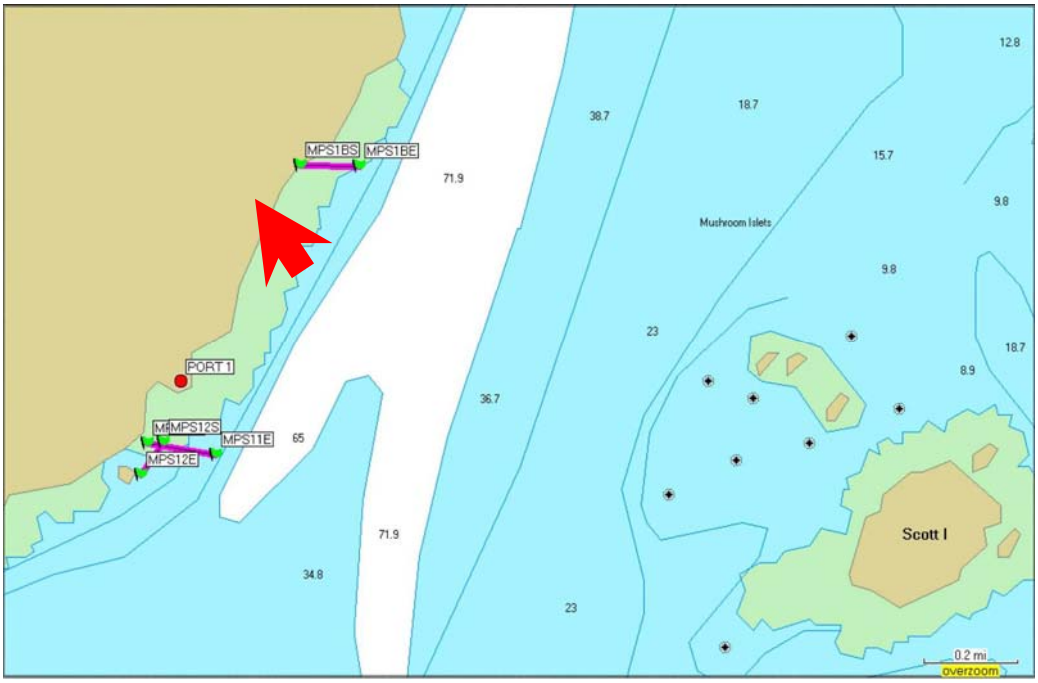

MPS1BS
MPS1BE
PORT 1
MPS12S
MPS11E
MPS12E
71.9
38.7
18.7
12.8
15.7
9.8
Mushroom Islets
9.8
23
18.7
8.9
36.7
65
71.9
34.8
23
Scott I
0.2 mi
overzoom

TABLE 12C-4
Benthic reconnaissance dive survey of algae, epifaunal invertebrates, and fishes from marine Port Site 2, Iniskin Bay, August 31, 2004.

Site Transect Name:	Port Site 2
Time:	1015-1032
Tidal Height (ft re: MLLW):	-2.6 to -2.5
Actual Depth (ft):	8 - 31
Adjusted Depth (ft re: MLLW):	10.6 - 33.5
Transect Distance (ft):	307
Substrate:	Sand/silt/gravel throughout
Visibility (ft):	1 - 2
Tidal state:	Slight ebb tide
Divers:	S. Jewett/S. Harper
TAXON	**COMMON NAME**
ARTHROPODA—Crustacea	
Balanus sp.	Barnacle
ECTOPROCTA—Flustrellidae	Bryozoan

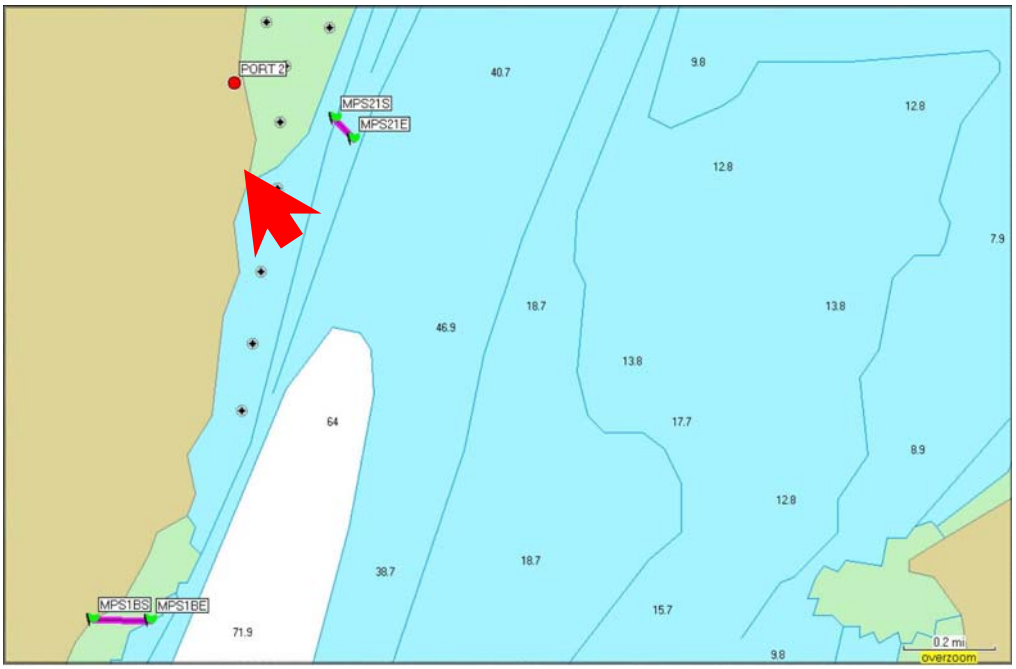


TABLE 12C-5
Benthic reconnaissance dive survey of algae, epifaunal invertebrates, and fishes from marine Port Site 4, North Head, Iliamna Bay, August 30, 2004.

Site Transect Name:	Port Site 4
Time:	1000-1105
Tidal Height (ft re: MLLW):	-2.8 to -0.6
Actual Depth (ft):	5 - 19
Adjusted Depth (ft re: MLLW):	7.8 - 19.6
Transect Distance (ft):	1214
Substrate:	Boulder @ 5 ft; sand @ 19 ft
Visibility (ft):	2 @ 5 ft; 10 @ 19 ft
Tidal state:	Strong flood
Divers:	S. Jewett/S. Harper
TAXON	**COMMON NAME**
ALGAE—Chlorophyta	Green algae
Ulva sp.	Sea Lettuce
ALGAE—Phaeophyta	Brown algae
Desmarestia aculeata	Witch's Hair
Agarum clathratum	Shotgun kelp
Laminaria bongardiana	Split kelp
Fucus gardneri	Bubble kelp
ALGAE—Rhodophyta	Red algae
Constantinea sp.	Cup and Saucer
Neodilsea borealis	Northern Red Blade
PORIFERA	
Suberites sp.	Sponge
CNIDARIA—Hydrozoa	
Sertulariidae	Hydroid
Campanularidae	Hydroid
CNIDARIA—Anthozoa	
Unid. White/yellow anemone	Sea anemone
Urticina crassicornis	Christmas sea anemone
Pachycerianthus fimbriatus	Tubiculous anemone
ANNELIDA—Polychaeta	
Schizobranchia insignis?	Polychaete
Potamilla sp.	Polychaete
MOLLUSCA—Gastropoda	
Lacuna vincta	Snail

APPENDIX TABLE 12C-5 CONT'D
Benthic reconnaissance dive survey of algae, epifaunal invertebrates, and fishes from marine Port Site 4, North Head, Iliamna Bay, August 30, 2004.

TAXON	COMMON NAME
MOLLUSCA—Gastropoda (Cont'd)	
Neptunea lyrata	Snail
Hermissenda crassicornis	Nudibranch
MOLLUSCA—Polyplacophora	
Ischnochiton sp.	Chiton
Tonicella lineata	Chiton
Tonicella insignis	Chiton
ARTHROPODA—Crustacea	
Balanus sp.	Barnacle
Pagurus beringanus	Hermit crab
Pagurus ochotensis	Hermit crab
Elassochirus tenuimanus	Hermit crab
E. gilli	Hermit crab
Oregonia gracilis	Decorator crab
Pugettia gracilus	Kelp crab
ECTOPROCTA	
Flustrellidae	Bryozoan
Membraniporidae	Bryozoan
ECHINODERMATA—Asteroidea	
Henricia leviuscula	Blood sea star
Leptasterias spp.	Sea star
Leptasterias alaskensis	Sea star
Crossaster papposus	Sea star
ECHINODERMATA—Echinoidea	
Echinarachnius parma	Sand dollar
ECHINODERMATA—Holothuroidea	
Cucumaria fallax	Sea cucumber
CHORDATA—Pisces	
Unid. Flatfish	Flatfish
Platichthys stellatus	Starry Flounder

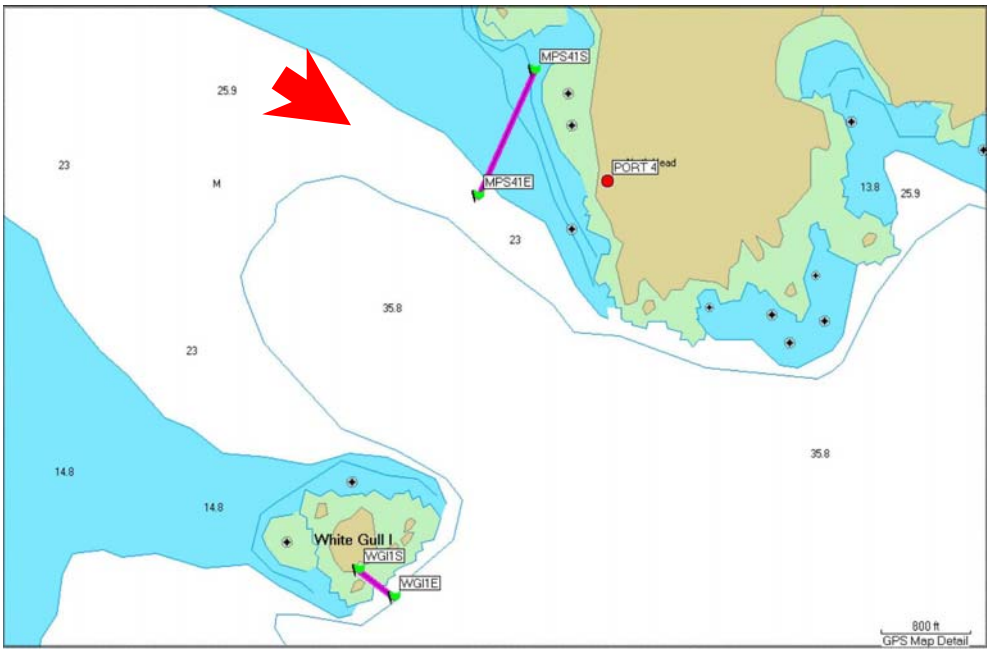

MPS41S
MPS41E
PORT 4
25.9
23
M
23
35.8
23
14.8
14.8
13.8
25.9
35.8
White Gull I
WGI1S
WGI1E
800 ft
GPS Map Detail

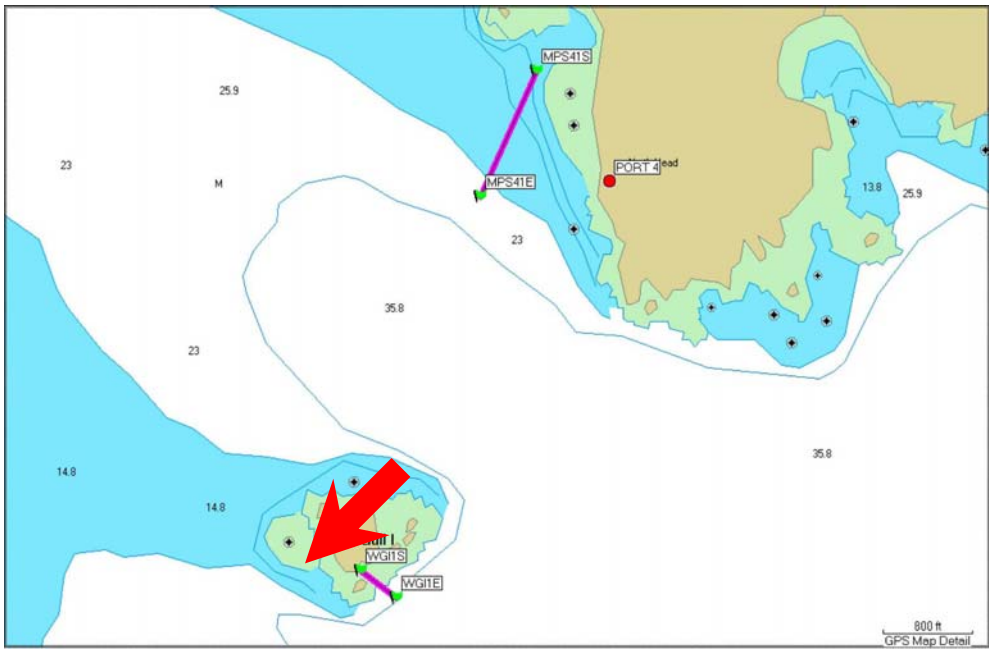
TABLE 12C-6
Benthic reconnaissance dive survey of algae, epifaunal invertebrates, and fishes from the southeast side of White Gull Island, Iliamna Bay, August 30, 2004.

Site Transect Name:	White Gull Island
Time:	1775-1837
Tidal Height (ft re: MLLW):	+12.5 to +9.7
Actual Depth (ft):	16 - 37
Adjusted Depth (ft re: MLLW):	3.5 - 27.3
Transect Distance (ft):	402
Substrate:	Boulder @ 16 ft; gravel @ 37 ft
Visibility (ft):	4 - 6
Tidal state:	Slight ebb tide
Divers:	S. Jewett/H. Chenelot/S. Harper

TAXON	**COMMON NAME**
ALGAE—Chlorophyta	Green algae
Acrosiphonia arcta	Arctic Sea Moss
ALGAE—Phaeophyta	Brown algae
Desmarestia aculeata	Witch's Hair
Alaria sp.	
Agarum clathratum	Shotgun kelp
Laminaria bongardiana	Split kelp
Fucus gardneri	Bubble kelp
ALGAE—Rhodophyta	Red algae
Constantinea sp.	Cup and Saucer
Opuntiella californica	Red Opuntia
Phycodrys riggii	
Scagelia sp.	
Sparlingla pertusa	
PORIFERA	
Suberites sp.	Sponge
CNIDARIA—Hydrozoa	Hydroid
CNIDARIA—Anthozoa	
Urticina crassicornis	Sea anemone
Metridium giganteum	Sea anemone
MOLLUSCA—Gastropoda	
Tectura scutum	Snail
Lacuna vincta	Snail

TABLE 12C-6 CONT'D
Benthic reconnaissance dive survey of algae, epifaunal invertebrates, and fishes from the southeast side of White Gull Island, Iliamna Bay, August 30, 2004.

TAXON	COMMON NAME
MOLLUSCA—Gastropoda (Cont'd)	
Margarites pupillus	Snail
Neptunea lyrata	Snail
Fusitriton oregonensis	Snail
Hermissenda crassicornis	Nudibranch
Onchidoris bilamellata	Nudibranch
MOLLUSCA—Polyplacophora	
Ischnochiton sp.	Chiton
Mopalia ciliata	Chiton
Tonicella lineata	Chiton
Tonicella insignis	Chiton
BRYOZOA	
Carbasea sp.	Bryozoan
ARTHROPODA—Crustacea	
Balanus glandula	Barnacle
Heptacarpus brevirostris	Shrimp
Pagurus beringanus	Hermit crab
P. hirsutiusculus	Hermit crab
Elassochirus tenuimanus	Hermit crab
E. gilli	Hermit crab
ECTOPROCTA	Bryozoan
ECHINODERMATA—Asteroidea	
Henricia leviuscula	Blood sea star
Pteraster sp.	
Leptasterias spp.	Sea star
Crossaster papposus	Sea star
ECHINODERMATA—Ophiuroidea	
Ophiopholus aculeata	Brittle star
ECHINODERMATA—Holothuroidea	
Eupentacta pseudoquinquesemita	Sea cucumber
UROCHORDATA—Tunicata	
Psolus chitonoides	Tunicate
CHORDATA—Pisces	
Hexagrammos stelleri	Whitespotted greenling


MPS41S
MPS41E
PORT 4
25.9
23
M
23
35.8
23
14.8
14.8
13.8
25.9
35.8
WGI1S
WGI1E
800 ft
GPS Map Detail

APPENDIX 12-D
Cook Inlet Regional Citizen's Advisory Council
Intertidal Habitat Mapping

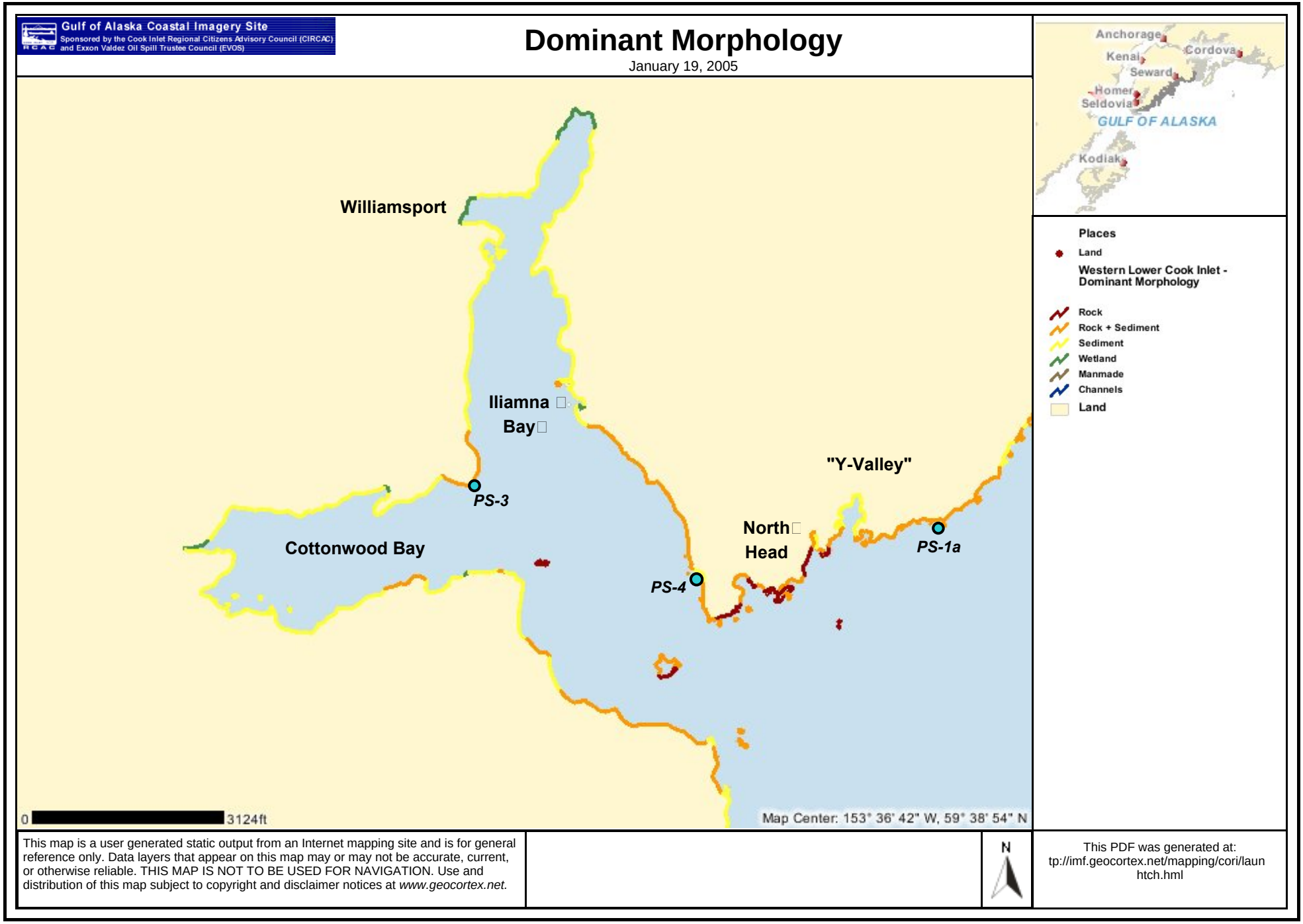

Gulf of Alaska Coastal Imagery Site
Sponsored by the Cook Inlet Regional Citizens Advisory Council (CIRCAC) and Exxon Valdez Oil Spill Trustee Council (EVOS)
Dominant Morphology
January 19, 2005
Williamsport
Iliamna Bay
"Y-Valley"
PS-3
Cottonwood Bay
North Head
PS-1a
PS-4
0
3124ft
Map Center: 153° 36' 42" W, 59° 38' 54" N
Anchorage
Kenai
Cordova
Seward
Homer
Seldovia
GULF OF ALASKA
Kodiak
Places
Land
Western Lower Cook Inlet - Dominant Morphology
Rock
Rock + Sediment
Sediment
Wetland
Manmade
Channels
Land
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Figure 12-D-1

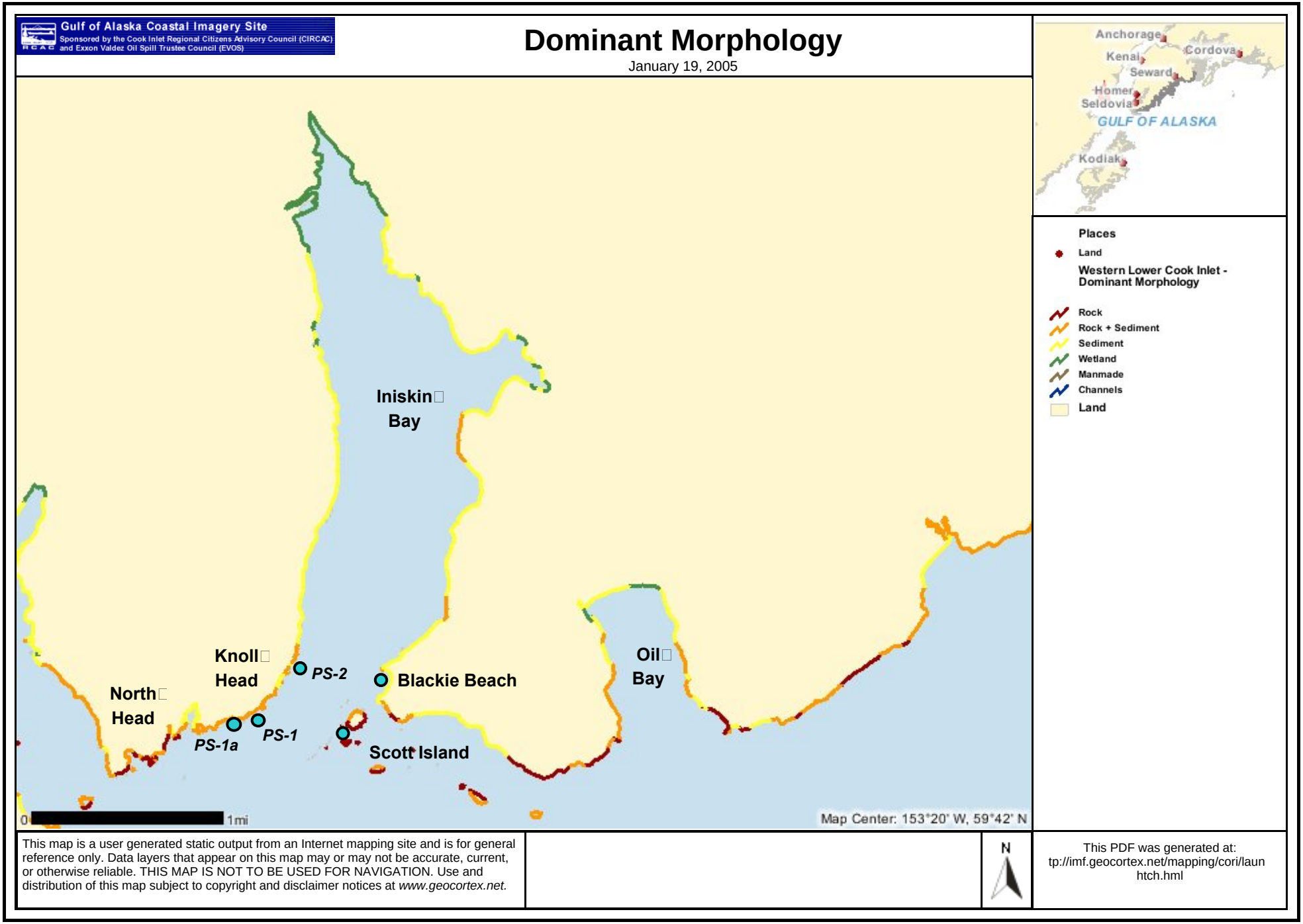
Gulf of Alaska Coastal Imagery Site
Sponsored by the Cook Inlet Regional Citizens Advisory Council (CIRCAC) and Exxon Valdez Oil Spill Trustee Council (EVOS)
Dominant Morphology
January 19, 2005
Anchorage
Kenai
Cordova
Seward
Homer
Seldovia
GULF OF ALASKA
Kodiak
Iniskin Bay
Knoll Head
North Head
PS-2
PS-1
PS-1a
Blackie Beach
Scott Island
Oil Bay
0
1mi
Map Center: 153°20' W, 59°42' N
Places
Land
Western Lower Cook Inlet - Dominant Morphology
Rock
Rock + Sediment
Sediment
Wetland
Manmade
Channels
Land
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Figure 12-D-2

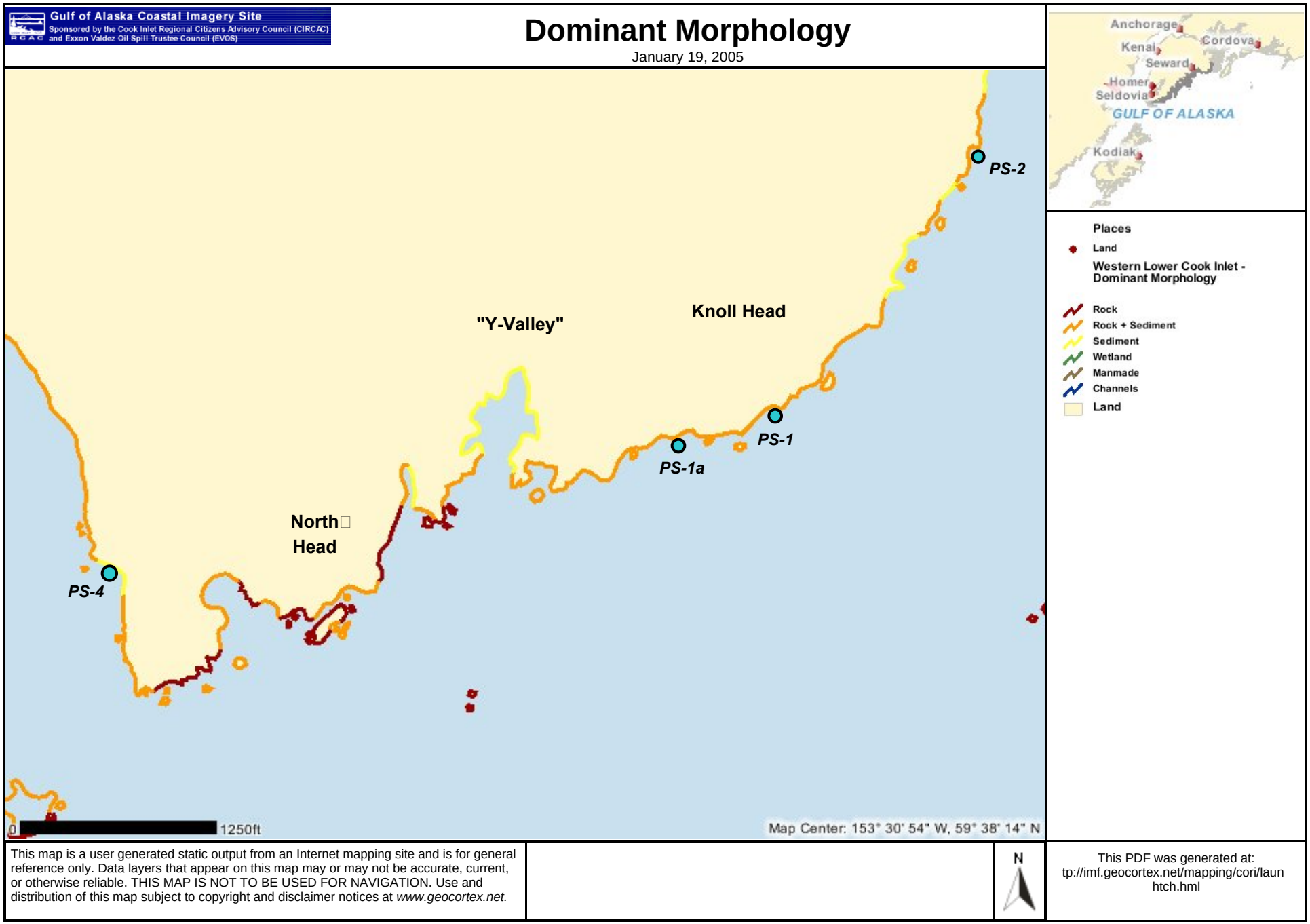
Gulf of Alaska Coastal Imagery Site
Sponsored by the Cook Inlet Regional Citizens Advisory Council (CIRCAC) and Exxon Valdez Oil Spill Trustee Council (EVOS)
Dominant Morphology
January 19, 2005
Anchorage
Kenai
Cordova
Seward
Homer
Seldovia
GULF OF ALASKA
Kodiak
PS-2
"Y-Valley"
Knoll Head
PS-1
PS-1a
North Head
PS-4
0
1250ft
Map Center: 153° 30' 54" W, 59° 38' 14" N
Places
Land
Western Lower Cook Inlet - Dominant Morphology
Rock
Rock + Sediment
Sediment
Wetland
Manmade
Channels
Land
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Figure 12-D-3

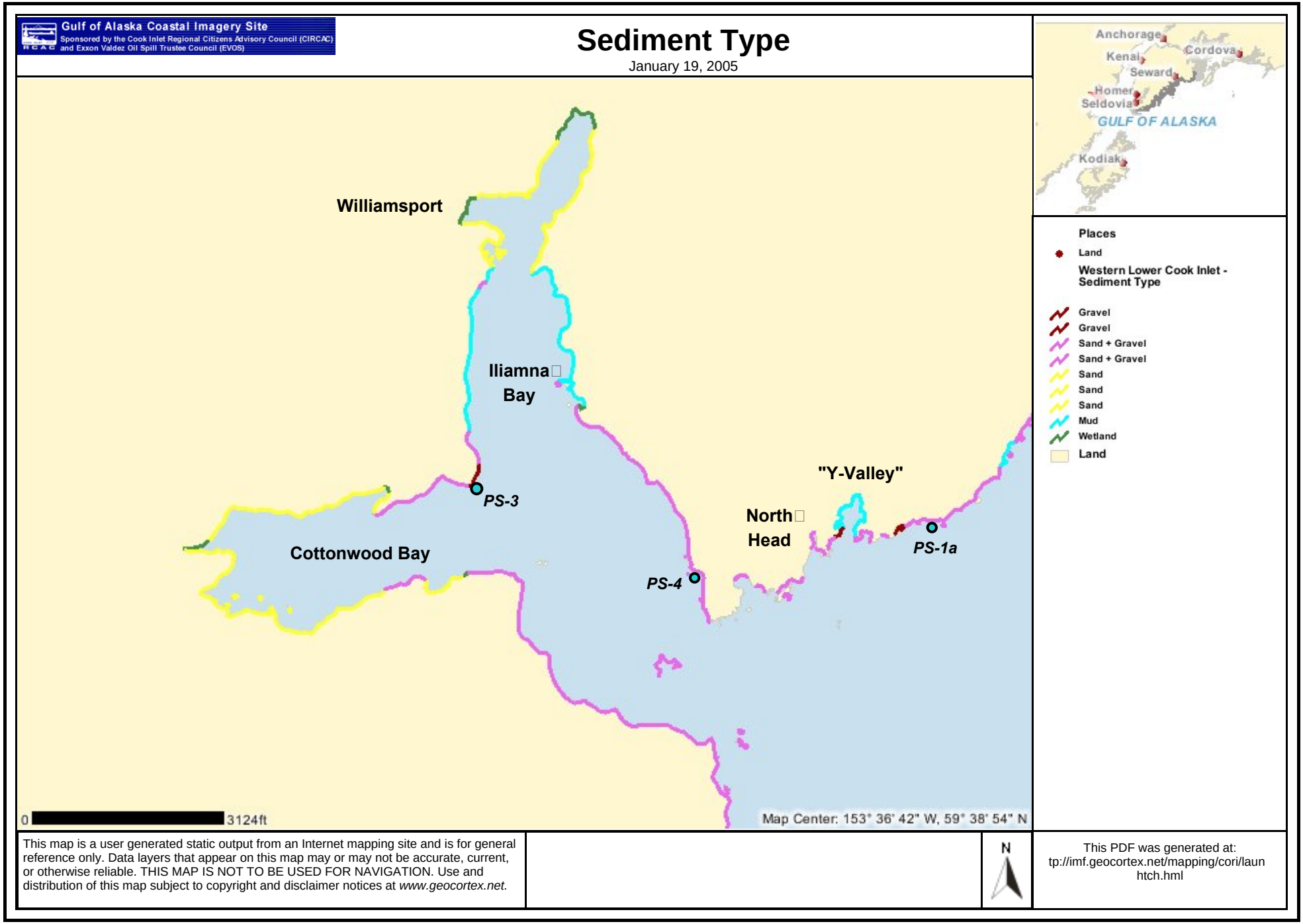
Gulf of Alaska Coastal Imagery Site
Sponsored by the Cook Inlet Regional Citizens Advisory Council (CIRCAC) and Exxon Valdez Oil Spill Trustee Council (EVOS)
Sediment Type
January 19, 2005
Williamsport
Iliamna Bay
PS-3
Cottonwood Bay
PS-4
North Head
"Y-Valley"
PS-1a
0
3124ft
Map Center: 153° 36' 42" W, 59° 38' 54" N
Anchorage
Kenai
Cordova
Seward
Homer
Seldovia
GULF OF ALASKA
Kodiak
Places
Land
Western Lower Cook Inlet - Sediment Type
Gravel
Gravel
Sand + Gravel
Sand + Gravel
Sand
Sand
Sand
Mud
Wetland
Land
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Figure 12-D-4

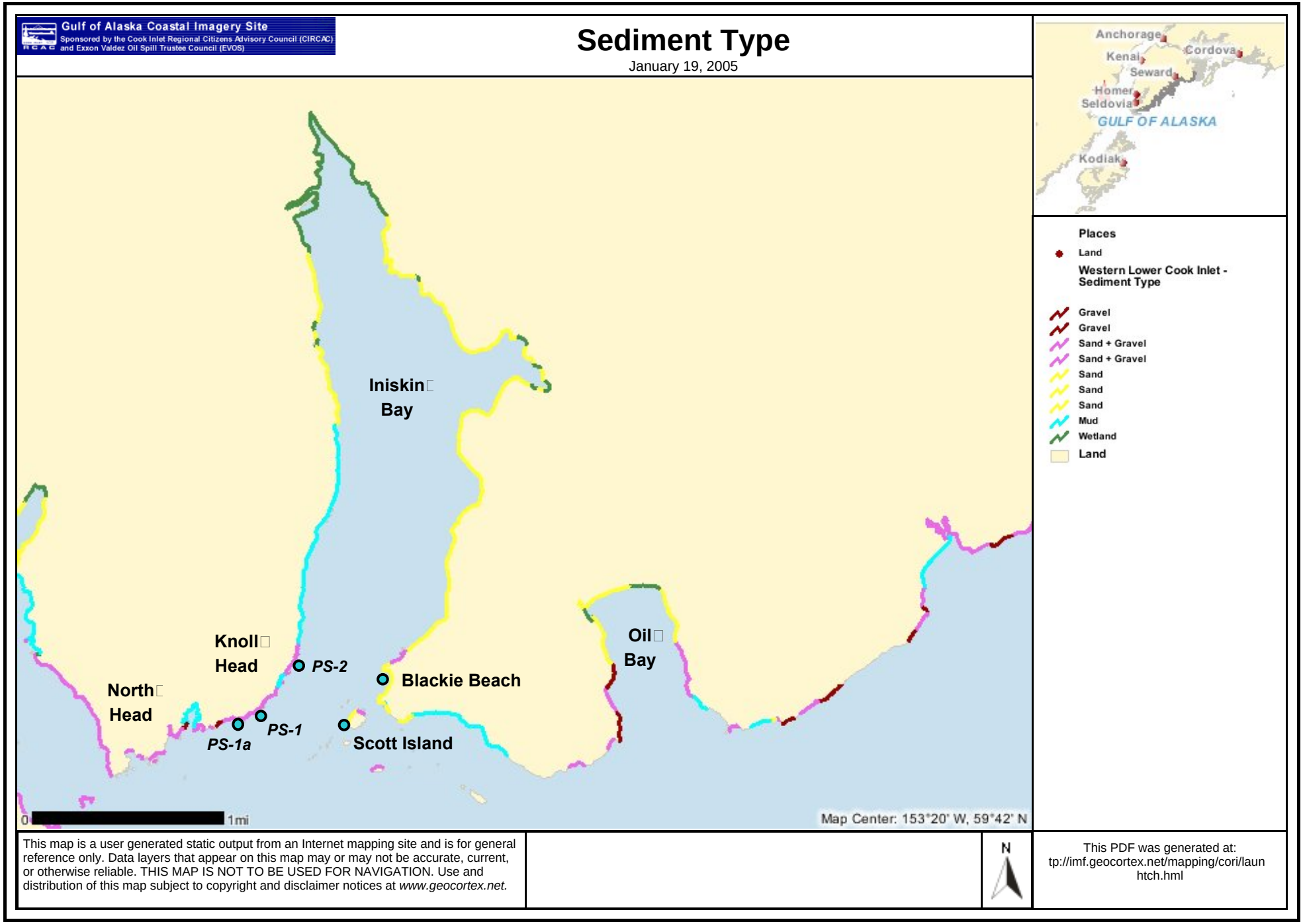
Gulf of Alaska Coastal Imagery Site
Sponsored by the Cook Inlet Regional Citizens Advisory Council (CIRCAC) and Exxon Valdez Oil Spill Trustee Council (EVOS)
Sediment Type
January 19, 2005
Anchorage
Kenai
Cordova
Seward
Homer
Seldovia
GULF OF ALASKA
Kodiak
Iniskin Bay
Knoll Head
PS-2
Blackie Beach
North Head
PS-1
PS-1a
Scott Island
Oil Bay
0
1mi
Map Center: 153°20' W, 59°42' N
Places
Land
Western Lower Cook Inlet - Sediment Type
Gravel
Gravel
Sand + Gravel
Sand + Gravel
Sand
Sand
Sand
Mud
Wetland
Land
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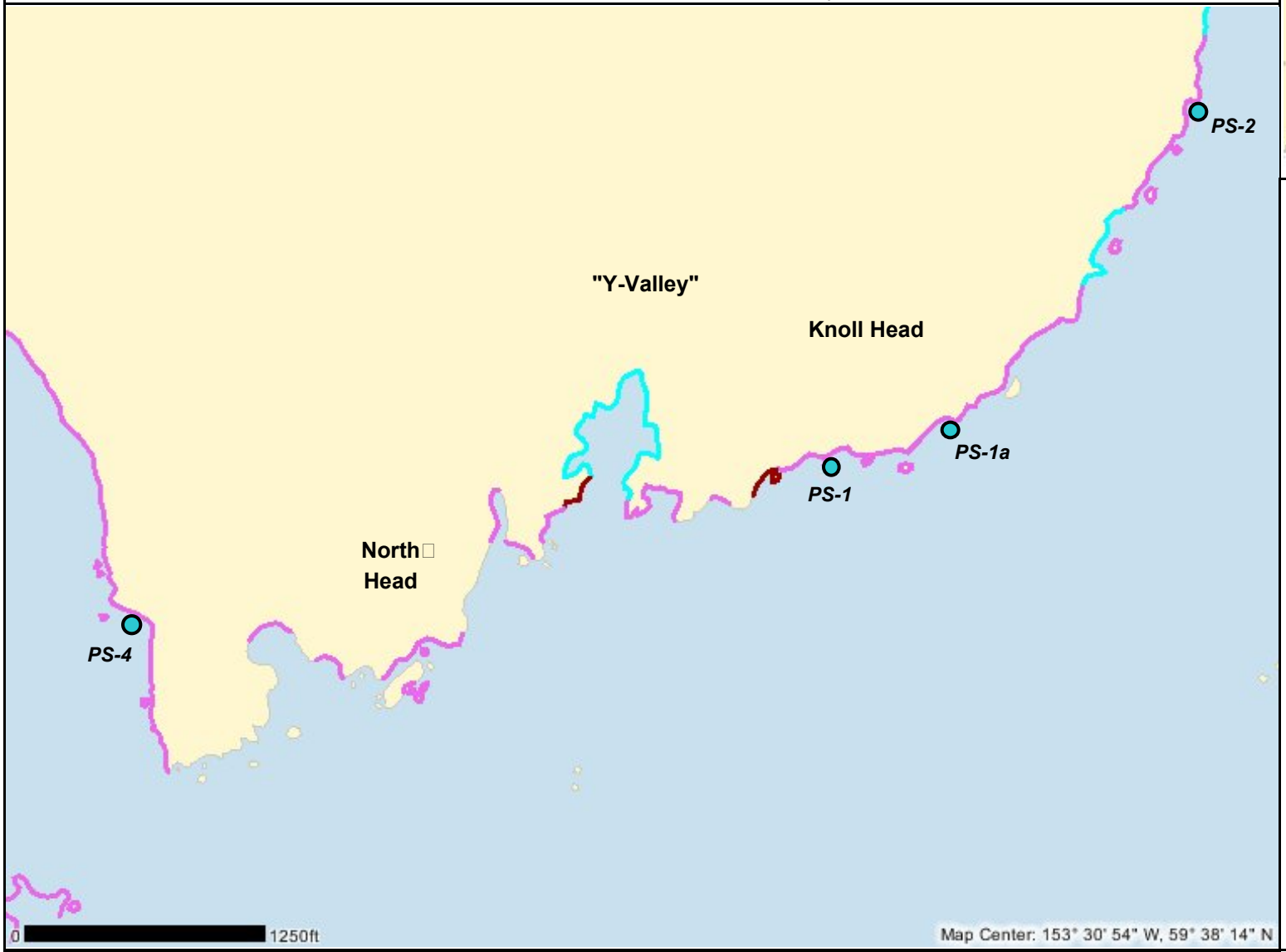
Figure 12-D-5

Gulf of Alaska Coastal Imagery Site
Sponsored by the Cook Inlet Regional Citizens Advisory Council (CIRCAC) and Exxon Valdez Oil Spill Trustee Council (EVOS)

Sediment Type

January 19, 2005



Places

- Land

Western Lower Cook Inlet - Sediment Type

- Gravel
- Gravel
- Sand + Gravel
- Sand + Gravel
- Sand
- Sand
- Sand
- Mud
- Wetland
- Land

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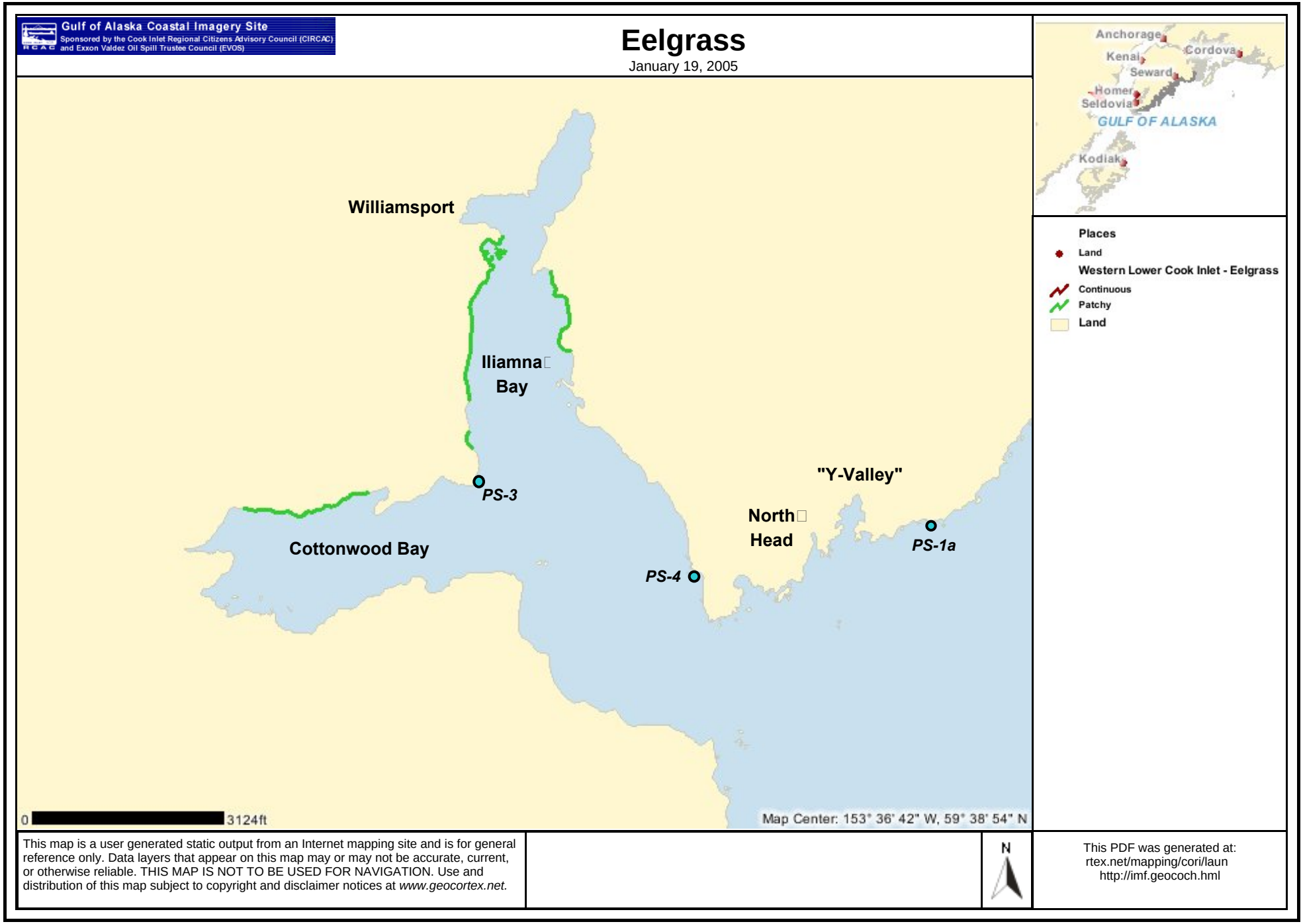
Figure 12-D-6


Gulf of Alaska Coastal Imagery Site
Sponsored by the Cook Inlet Regional Citizens Advisory Council (CIRCAC) and Exxon Valdez Oil Spill Trustee Council (EVOS)
Eelgrass
January 19, 2005
Anchorage
Kenai
Cordova
Seward
Homer
Seldovia
GULF OF ALASKA
Kodiak
Williamsport
Iliamna Bay
PS-3
Cottonwood Bay
PS-4
North Head
"Y-Valley"
PS-1a
Places
Land
Western Lower Cook Inlet - Eelgrass
Continuous
Patchy
Land
0
3124ft
Map Center: 153° 36' 42" W, 59° 38' 54" N
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http://imf.geococh.hml

Figure 12-D-7

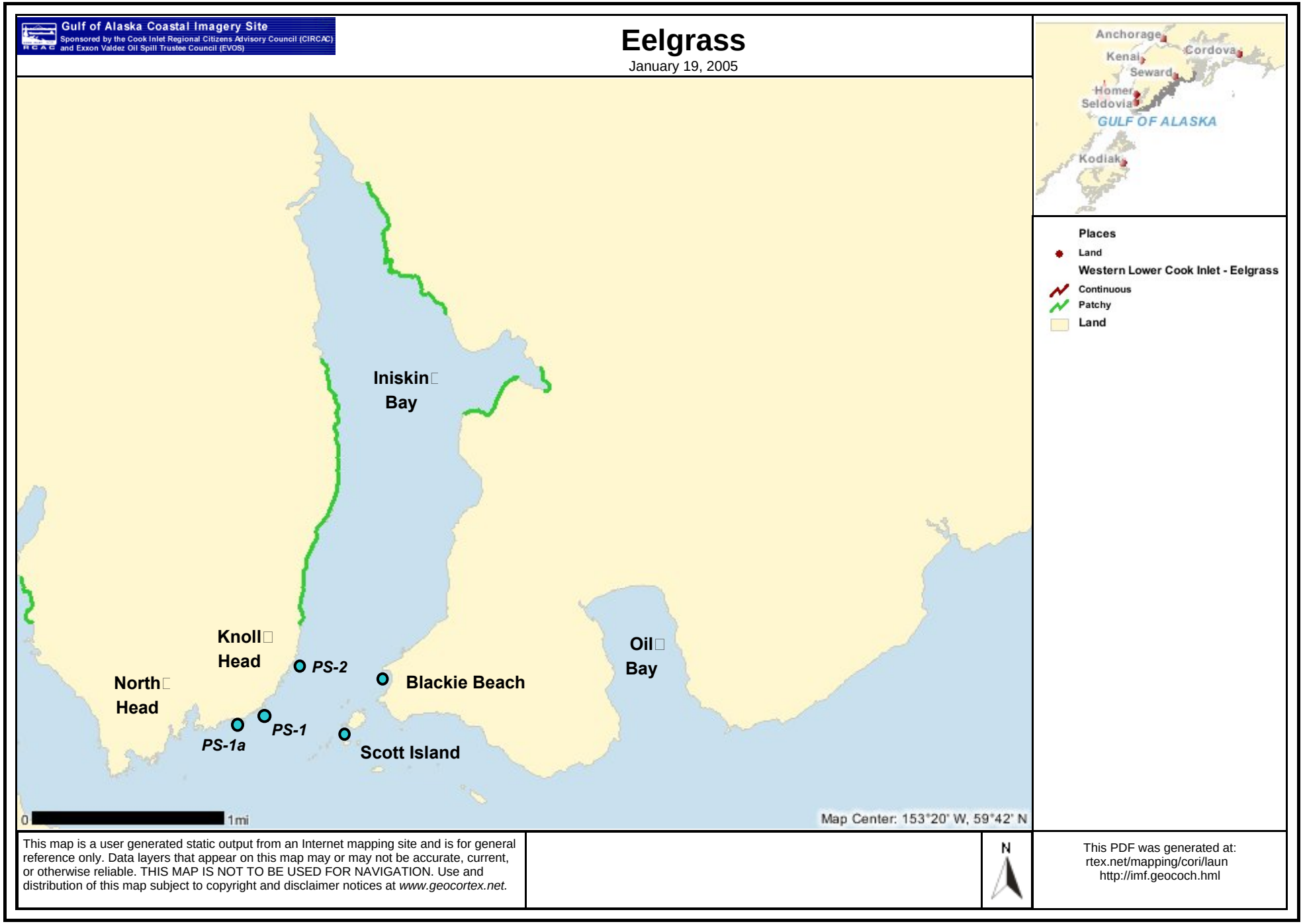
Gulf of Alaska Coastal Imagery Site
Sponsored by the Cook Inlet Regional Citizens Advisory Council (CIRCAC) and Exxon Valdez Oil Spill Trustee Council (EVOS)
Eelgrass
January 19, 2005
Iniskin Bay
Knoll Head
North Head
PS-2
PS-1
PS-1a
Blackie Beach
Scott Island
Oil Bay
0
1mi
Map Center: 153°20' W, 59°42' N
Anchorage
Kenai
Cordova
Seward
Homer
Seldovia
GULF OF ALASKA
Kodiak
Places
Land
Western Lower Cook Inlet - Eelgrass
Continuous
Patchy
Land
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Figure 12-D-8